Public Document

TWENTY-THIRD ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.,

BEING PART III. OF THE FORTY-EIGHTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1911.

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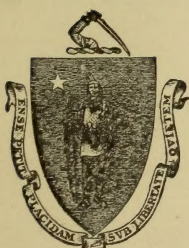

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Approved by
The State Board of Publication.

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MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

PART I.

DETAILED REPORT OF THE EXPERIMENT STATION.

INTRODUCTION.

In accordance with the provision of the act of the Legislature relative to the publication of the reports of the Massachusetts Agricultural College, the report of the experiment station, which is a department of the college, is presented in two parts. Part I. contains the formal reports of the director, treasurer and heads of departments, and papers of a technical character giving results of experiments carried on in the station. This will be sent to agricultural colleges and experiment stations and to workers in these institutions, as well as to libraries. Part I. will be published also in connection with the report of the Secretary of the State Board of Agriculture, and will reach the general public through that channel. Part II. will contain papers of a popular character, and will be sent to persons on our mailing list.

WM. P. BROOKS,
Director.

CONTENTS.

Part I.

MASSACHUSETTS

AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-THIRD ANNUAL REPORT.

Part I.

ORGANIZATION.

Committee on Experiment Department.

Charles H. Preston, *Chairman.*
J. Lewis Ellsworth.
Arthur H. Pollard.
Charles E. Ward.
Harold L. Frost.
The President of the College, *ex officio.*
The Director of the Station, *ex officio.*

Station Staff.

William P. Brooks, Ph. D., Director, 28 Northampton Road.
Joseph B. Lindsey, Ph. D., Vice-Director, 47 Lincoln Avenue.
Fred C. Kenney, Treasurer, Mount Pleasant.
Charles R. Green, B.Agr., Librarian, Mount Pleasant.

Department of Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., Chemist, 47 Lincoln Avenue.
Edward B. Holland, M.Sc., Associate Chemist, in charge of Research Division, 28 North Prospect Street.
Fred W. Morse, M.Sc., Research Chemist, 44 Pleasant Street.
Henri D. Haskins, B.Sc., In charge of Fertilizer Section, 87 Pleasant Street.
Philip H. Smith, B.Sc., In charge of Feed and Dairy Section, 102 Main Street.
Lewell S. Walker, B.Sc., Assistant, 19 Phillips Street.
James C. Reed, B.Sc., Assistant, Nutting Avenue.
Joseph F. Merrill, B.Sc., Assistant, North Prospect Street.
Clement L. Perkins, B.Sc., Assistant, 32 North Prospect Street.
Joseph P. Howard, Collector, North Amherst, Mass.
Harry J. Allen, Laboratory Assistant, 89 Main Street.
James R. Alcock, Assistant in Animal Nutrition, North Amherst, Mass.

Department of Agriculture.

William P. Brooks, Ph.D., Agriculturist, 28 Northampton Road.
H. J. Franklin, Ph.D., In charge of Cranberry Investigation, Wareham, Mass.
Erwin S. Fulton, B.Sc., First Assistant, North Amherst, Mass.
Edwin F. Gaskill, B.Sc., Second Assistant, North Amherst, Mass.

Department of Horticulture.

Frank A. Waugh, M.Sc., Horticulturist, Massachusetts Agricultural College.
Fred C. Sears, M.Sc., Pomologist, Mount Pleasant.
Jacob K. Shaw, M.Sc., Assistant Horticulturist, 1 Allen Street.
David W. Anderson, B.Sc., Graduate Assistant, 32 North Prospect Street.

Department of Botany and Vegetable Pathology.

George E. Stone, Ph.D., Botanist and Vegetable Pathologist, Mount Pleasant.
George H. Chapman, M.Sc., Assistant Botanist, 13 Fearing Street.
Sumner C. Brooks, B.Sc., Assistant Botanist, 28 Northampton Road.

Department of Entomology.

Henry T. Fernald, Ph.D., Entomologist, 44 Amity Street.
Burton N. Gates, Ph.D., Apiarist, 42 Lincoln Avenue.
Arthur I. Bourne, B.A., Assistant in Entomology, 66 North Pleasant Street.

Department of Veterinary Science.

James B. Paige, B.Sc., D.V.S., Veterinarian, 42 Lincoln Avenue.

Department of Meteorology.

John E. Ostrander, A.M., C.E., Meteorologist, 35 North Prospect Street.
Charles M. Damon, Observer, Massachusetts Agricultural College.

Other Officers of the Experiment Station.

Miss Rose J. Brown, Secretary to the Director, Draper Hall.
Miss Jessie V. Crocker, Stenographer, Department of Botany and Vegetable Pathology, Sunderland, Mass.
Miss Harriet Cobb, Stenographer, Department of Plant and Animal Chemistry, 35 North Pleasant Street.
Miss Bridie O'Donnell, Stenographer, Department of Entomology, Hadley, Mass.
Miss Alice M. Howard, Stenographer, Department of Plant and Animal Chemistry, North Amherst, Mass.

REPORT OF THE DIRECTOR.

Changes in Staff.

The experiment station staff during the past year has suffered the loss of two of its oldest and strongest men: Dr. C. A. Goessmann, who died in September, and Dr. C. H. Fernald, who retired on a Carnegie pension at about the same time.

Dr. Goessmann had been connected with the experiment station from the very first inception of station work in the State, in 1882. He was director of the State Experiment Station until it was combined with the station later organized under the Hatch act, in 1895. Dr. Goessmann, however, although giving up his duties as director at that time, retained active supervision of the inspection of commercial fertilizers and the general work in the fertilizer and soil laboratory until his retirement in 1907. Subsequent to retirement he was retained as consulting chemist, and continued his active interest in the station and its work until almost the end of his life. Goessmann was one of the great pioneers in the work of agricultural investigation. It seems eminently fitting, therefore, to present at this time a brief account of his life and work. Dr. J. B. Lindsey, vice-director and chemist of the station, one of Dr. Goessmann's pupils, peculiarly fitted through long and close association with him to write such an account and estimate, has at my request kindly prepared a tribute which will be found in following pages.

Dr. Charles H. Fernald, head of the entomological department of the college and station, became connected with the station work at the time of organization under the Hatch act, and continued at the head of the entomological department until his retirement, the first of September last. Dr. Fernald's work was of great value to the station. Of him, as of Goessmann, it is largely true that to a considerable extent his work was of a pioneer character. He was one of the earliest station entomologists, and as such he had much to do with the establishment of a

general policy for station entomological work. It was in considerable measure due to his influence that the policy that original descriptions of insects should not be published in ordinary station bulletins was adopted. During the early years of his station activities he devoted a large amount of time to the study of the gypsy moth, and the recognition of this insect and the scientific work connected with it were due to his efforts. His work in connection with the gypsy moth greatly strengthened the entomological department of the station, and resulted in making its work better understood and appreciated. Dr. Fernald's bulletin on household insects is believed to have been the first of its kind; but the value of such work was promptly recognized. His monograph papers, which have been published as station bulletins, are constantly quoted as standard works on the subjects of which they treat. He was the first to undertake investigations on cranberry insects, and the work he did in relation to them proved of great value to cranberry growers. His work in systematic and economic entomology has been extensive, and he instituted numerous lines of investigation which have since been greatly extended and developed by others better situated to prosecute them. While Professor Fernald did a very large amount of strong original work, I think it will be generally admitted by those who know him and his influence that his greatest work was in the line of stimulating others by his personality to accomplish what he himself had no opportunity to do.

The death of Dr. Goessmann did not involve important changes in the chemical department as his services during the past few years had been simply advisory, and, owing to failing health, largely nominal during the last year or two.

On the retirement of Dr. C. H. Fernald, his son, Dr. H. T. Fernald, was made head of the entomological department. The retirement of the elder Fernald imposed additional duties on his son, and some reorganization of the department became necessary. Mr. John N. Summers, a graduate assistant, who had been giving one-half his time to the experiment station, retired, and in his place, Mr. A. I. Bourne, B. A., who has had a valuable experience in graduate and investigational work, was made assistant. Mr. Bourne is allowed a certain amount of time for

graduate study, but he will give nearly all his attention to the work in the experiment station. His employment relieves Dr. H. T. Fernald of almost all of the routine work of the entomological department, and of the necessity of giving direct personal attention to the experimental work in its simpler phases. This will make it possible for Dr. Fernald to devote a very large proportion of his time to research work in entomology.

In this connection attention should be called to the extremely valuable work which Mrs. C. H. Fernald, with some clerical assistance, carried on for a period of more than twenty years, in editing the index cards with references to entomological literature. The work of Mrs. Fernald has been characterized by extreme accuracy and thoroughness, and up to the present time no less than 50,000 cards, with many times that number of references, have been prepared. A large proportion of the entries on these are in Mrs. Fernald's own hand. Advancing years have led Mrs. Fernald to desire to be relieved of this work, so important to all investigators in all lines of entomology, and arrangements have been completed whereby it will be continued under Dr. H. T. Fernald's supervision by his stenographer and clerk, Miss O'Donnell.

The retirement of Dr. R. D. MacLaurin, referred to in my last annual report, left a vacancy in the research division of the chemical department. This place was filled in January by the temporary appointment of Fred W. Morse, Ph.D., for many years chemist of the New Hampshire Experiment Station. His appointment was made permanent in July. Mr. Morse is devoting himself entirely to research problems connected with the nutrition of crops and the productive capacity of soils.

The staff of the station has been strengthened by the addition of two men; David W. Anderson, B.Sc., has been made graduate assistant in the department of horticulture; Sumner C. Brooks, B.Sc., has been made assistant in the department of botany and plant pathology. The appointment of these men relieves their superiors in these departments of routine work, and will enable them to devote their time in larger measure to research.

The work of the station has been broadened in scope and fur-

ther strengthened by the appointment of Dr. B. N. Gates, Ph.D., as apiarist. It is the expectation that Dr. Gates will devote about one-quarter of his time, so far as possible consecutively, to research work on problems connected with beekeeping.

Mr. James Alcock replaces Mr. Roy Gaskill in charge of the animals used in feeding and digestion experiments, and Clement L. Perins, B.Sc., has taken the place of Carl D. Kennedy as assistant in the chemical laboratory.

Lines of Work.

There has been no essential change in the character of station work during the year. It covers a field of constantly broadening scope and increases steadily in amount. As heretofore, our efforts may be classed under the following principal heads: general experiments, research, control and dissemination of information.

The relation of the lines of work which come under the last class to the possibility of adequate attention to and of financial support for the experiment and research, for carrying on which the funds for the support of the station which come from the federal government are designed, is so vital that while in logical sequence these lines of work would seem to come last, they will be considered first.

Dissemination of Information.

The principal methods whereby the station now endeavors to serve the public by dissemination of information are by means of its publications, through private correspondence, through lectures by members of its staff and by demonstrations.

Publications. — Our publications are of three kinds, an annual report in two parts, bulletins and circulars. The following tables show the publications of the year 1910 and those still available for distribution: —

Publications during 1910.

Annual report: —

Parts I. and II. 338 pages.

Bulletins: —

No. 132. Inspection of Commercial Feed Stuffs, P. H. Smith and J. C. Reed. 64 pages.

No. 133. Green Crops for Summer Soiling, J. B. Lindsey. 20 pages.
No. 134. The Hay Crop, William P. Brooks. 68 pages.
No. 135. Inspection of Commercial Fertilizers, H. D. Haskins, L. F. Walker and J. F. Merrill. 76 pages.
Meteorological bulletins, 12 numbers. 2 pages.

Circulars:

No. 26. Fertilizers for Potatoes, William P. Brooks. 4 pages.
No. 27. Seeding Mowings, William P. Brooks. 8 pages.
No. 28. Rules relative to Testing Dairy Cows. 8 pages.
No. 29. Chemical Analysis of Soils, William P. Brooks. 4 pages.

Miscellaneous circulars (unnumbered): —

Fertilizers for Corn, William P. Brooks. 2 pages.
Home-mixed Fertilizers, William P. Brooks. 4 pages.
Fertilizers for Turnips, Cabbages and Other Crucifers, William P. Brooks. 2 pages.
Dairymen losing Money on Low-grade Feeds, J. B. Lindsey. 2 pages.
Orchard Experiment, William P. Brooks. 2 pages.
Summer Soiling Crops, P. H. Smith. 1 page.
Balanced Rations for Business Cows, J. B. Lindsey. 2 pages.
Corn for the Silo. 2 pages.

Publications Available for Free Distribution.

Bulletins: —

No. 33. Glossary of Fodder Terms.
No. 68. Fertilizer Analyses.
No. 76. The Imported Elm-leaf Beetle.
No. 83. Fertilizer Analyses.
No. 84. Fertilizer Analyses.
No. 89. Fertilizer Analyses.
No. 90. Fertilizer Analyses.
No. 103. Fertilizer Analyses.
No. 113. Fertilizer Analyses.
No. 115. Cranberry Insects.
No. 121. Seed Separation and Germination.
No. 123. Fungicides, Insecticides and Spraying Directions.
No. 124. Bee Diseases in Massachusetts.
No. 125. Shade Trees.
No. 126. Insects Injurious to Cranberries and how to fight them.
No. 127. Inspection of Commercial Fertilizers, 1908.
No. 130. Meteorological Summary — Twenty Years.
No. 131. Inspection of Commercial Fertilizers, 1909.
No. 132. Inspection of Commercial Feed Stuffs, 1910.
No. 133. Green Crops for Summer Soiling.
No. 134. The Hay Crop.
No. 135. Inspection of Commercial Fertilizers, 1910.

No. 136. Inspection of Commercial Feed Stuffs, 1911.
Technical Bulletin No. 2. The Graft Union.
Technical Bulletin No. 3. The Blossom End Rot of Tomatoes.
Index to bulletins and annual reports of the Hatch Experiment Station previous to June, 1895.
Index to bulletins and annual reports, 1888–1907.
Annual reports: 10th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 20th, 21st, Part II., 22d, Parts I. and II.

So far as our publications treat primarily of the results of station observation, experiment and research, they are to be looked upon as a necessary and important feature of station activity, — indeed, to be the crowning result of such activity; but the demand for bulletins and circulars of information of a general character, already widespread, is most active, insistent and growing, and the force of circumstances has seemed to compel us to make at least some effort to meet it. To fully do so has been impossible; indeed, must probably be recognized as in the very nature of things always likely to remain so, since nothing less than a complete library covering every conceivable agricultural topic would enable us to meet the demand.

A considerable share of the contents of the popular part of our annual report (Part II.), most of our circulars and some of our bulletins have, however, aimed to furnish information of a more or less general character on topics of immediate interest to the public. These papers have, it is true, been based upon our own observations and experiments in so far as possible, and to that extent are to be regarded as legitimate station publications. To a considerable extent, however, they are of a general character. United States funds cannot be used in their publication, and since the demands for other purposes upon the relatively small appropriation which comes to the station from the State are heavy, and since, further, furnishing this literature is rather extension than experiment, provision to carry the costs should be made in the extension department of the institution.

Circulation of Publications. — In accordance with an act of our Legislature Part I. of our annual report is printed with the report of the secretary of the State Board of Agriculture, and those on the mailing list of that Board will receive this publication. Five thousand copies of Part I. of our annual report also

are furnished to the station. These are sent to libraries and directors of agricultural experiment stations, to presidents and libraries of agricultural colleges, to the public libraries of Massachusetts, and all other libraries on our mailing list, to the mailing list of the United States Department of Agriculture and to those on our exchange list. This part of our annual report contains technical monographs giving the results of research work, and a large number of copies are reserved to meet future demands. Part II. of our annual report, which contains the more popular papers, and our bulletins are sent to all those on our general mailing list, to the public libraries of the State, to those on the mailing list of the United States Department of Agriculture likely to be interested, and to experiment stations and agricultural colleges. It is our aim to reserve a considerable number of each publication to meet subsequent demands, but the demand has grown so rapidly that the supply of most, as will be noted from the above list of available publications, has been exhausted. The meteorological bulletins are sent only to agricultural college and experiment station libraries, presidents and directors, to the Department of Agriculture and Office of Experiment Stations, to newspapers and to libraries and individuals who have especially requested them.

Our circulars are printed for use in connection with the correspondence of the station. It is only by the use of such circulars that we are able to give information and advice on the many problems on which we are consulted. These circulars are sent only as above stated or on request. An abstract of all important publications is furnished to the press, and requests for any issued will be met as long as the supply permits.

During the past year the revision of our general mailing list has been completed. As a result, 1,502 names were dropped from the list. The additions of the year have numbered 1,663 names. The total numbers on our general list and on the few special lists are shown by the following: —

Residents of Massachusetts,	13,361
Residents of other States,	2,381
Residents of foreign countries,	223
Newspapers,	524

Libraries,	292
Exchanges,	137
Cranberry growers,	1,437
Beekeepers,	2,638
Meteorological,	379

Correspondence. — The correspondence with private individuals who seek information or advice grows constantly and rapidly. During the year 1910 the number of letters of inquiry answered by the members of the station staff was 16,650. Replies to many of these involve investigation, and the demands upon the college and station men giving attention to this work are heavy and growing. There can be no doubt that such work is most helpful; numerous letters of appreciation testify to this fact. The work should be continued, but it is neither experiment nor research. It is rather a branch, and a most important one, of the extension propaganda, and should be provided for in that department.

Lectures and Demonstrations. — The demand for lectures and demonstrations by members of the station staff has much increased during the year. Relatively few of the requests for such services have been accepted. The number of such engagements met during the year has been 48. Work of this kind properly comes under the head of extension service, and yet as it helps in some measure to keep the station men, whose duties are for the most part of a character which keeps them closely confined, in touch with the public and its most vital problems, these opportunities are accepted in so far as is consistent with proper attention to the prosecution of those investigations and studies for which especially the station is maintained.

Future Provision for Extension Work. — The facts stated concerning the various lines of work which have for their object the dissemination of information must have made it apparent that this work now makes very heavy demands upon the time of station men. It already encroaches upon resources which would more properly be devoted to experiment and research. The authorities in Washington charged with the general oversight of the methods of expenditure of United States funds are most zealous, and rightly so, in their efforts to pre-

vent the diversion of these funds from the uses for which they are intended. The funds appropriated to the station by the State are not sufficient to cover this line of work and at the same time to provide funds to pay the costs of other lines of work now in progress which should be continued.

The desired relief may be obtained either by transfer of the lines of work under consideration to the extension department of the institution, or by the appropriation of funds from that department to cover the cost of employing competent secretarial assistants. The latter plan would, for a time at least, seem to have advantages, as with secretarial assistance the members of the station departments whose experience gives them the best foundation for it would be able to direct the work and to exercise a close oversight over it.

General Experiments.

Under this class are included a large number of experiments relative to the following subjects: soil tests with fertilizers, with different crops in rotation; comparisons of different materials which may be used as sources, respectively, of nitrogen, phosphoric acid and potash for different field and garden crops; the results of the use of lime; systems of fertilizing grass lands, both mowings and pastures; comparisons of fertilizers for both tree and bush fruits; different methods of applying manures; variety tests of field and garden crops and of fruits; trials of new crops; determinations of the digestibility of feedstuffs; methods of feeding for milk; systems and methods of management in feeding poultry for eggs; and co-operative work with selected farmers in the trial of crops and systems of fertilizing them. Few of these lines of experiment call for special comment here. Brief reports on some of them will be found under the departments in which they are being prosecuted.

Particular attention is directed to the fact that the plots used in the various experiments, involving the highly varied use of manures and fertilizers, and the many comparisons in progress, become increasingly valuable with the passing years. Many of these plots have been under definite and differing

manurial treatment for periods of time ranging from twelve to twenty-one years. They have taught many important lessons. If undisturbed, they will teach many more. They are teaching new lessons yearly as to the ultimate effects of differing treatments.

These facts are pointed out because the development of the institution on its educational side appears to threaten the integrity of important series of plots. They cannot, of course, be moved, nor indeed, in any true sense, can they be replaced. It is urged, therefore, that their value and the extreme undesirability of disturbing them be recognized in all plans for future growth and development.

Co-operative Experiments with Alfalfa. — During the past year thirty-three experiments with alfalfa have been made in ten different counties. Arrangements were completed for one experiment also in each of the counties Barnstable, Bristol and Dukes, but local conditions prevented the carrying out of the plans formed. Northern-grown seed treated with farmogerm for inoculation with nitrogen-fixing bacteria was used. The following extract from the directions sent to co-operating farmers will indicate what is believed to be a satisfactory method of preparing for the crop: —

(1) Plow in spring just as soon as possible after the ground can be worked.

(2) Apply lime at the rate of about 1½ tons to the acre and disk in at once.

(3) About ten days later apply the following mixture per acre: basic slag meal, 1,500 pounds, high-grade sulfate of potash, 400 to 500 pounds, and disk that in.

(4) Thereafter harrow about once in ten to twelve days, until you are ready to sow the seed, which should not be later than about July 27.

(5) When ready to sow the seed, apply per acre: nitrate of soda, 100 pounds, basic slag meal, 300 pounds, mixing them, and harrowing in lightly.

(6) Sow 30 pounds of seed per acre, in showery weather if possible, and cover as you would grass seed.

The fall months were exceptionally dry and therefore somewhat unfavorable, but in most cases the crops made a good start

and went into the winter in good condition, having made sufficient growth to afford the needed protection.

Research.

More research work has been done in the station during the past year than in any previous year of its history. The additions to our staff which have made this possible have already been referred to. Work still continues upon the various research problems which have been mentioned in earlier reports,[1] but the studies of Pyralidæ and Tortricidæ which Dr. C. H. Fernald has been conducting have been nearly brought to a conclusion, and the results in part already privately published.[2] The scope of our research work has been broadened during the year by the addition of two new lines of work, *i.e.*, an investigation of the solubility effect of ammonium sulfate on the soil of field A; and color vision in bees. The progress made in most of these lines of investigation has been satisfactory, but there has been some interruption on account of moving the entomological work into the new building, and on account of ill health of members of our staff, apparently due to overwork. In both departments in which such interruption has occurred changes (already referred to) have been made, including the provision of an additional assistant in each, which, it is believed, will make it possible to push the work of investigation more rapidly.

In the later pages of this report will be found a number of valuable technical papers based upon some of the investigations in progress. The more important of these are as follows: —

Studies in Milk Secretion.
The Determination of Arsenic in Insecticides.
The Purification of Insoluble Fatty Acids.
The Soluble Carbohydrates in Asparagus Roots.
Abnormalities of Stump Growth.
Climatic Adaptations of Apple Varieties.

The progress which has been made in our work with asparagus and cranberries, and the greatly increased facilities for

[1] For full list see Part I., twenty-second annual report.

[2] On the Dates of Jacob Hübner's Sammlung europäischer Schmetterlinge and Some of His Other Works, C. H. Fernald, Ph. D., author and publisher; The Genera of the Tortricidæ and their types, C. H. Fernald, Ph.D., author and publisher.

investigation in the interest of cranberry growers, are made the subjects of special comment which follows.

Asparagus Substation, Concord.

The details of the work in progress in the substation, maintained in the interest of asparagus growers in Concord, have been carefully looked after by Mr. Charles W. Prescott, to whom, as heretofore, we are greatly indebted for his lively interest and efficient supervision. The work has already given results of much interest, and is likely, I believe, to prove of great value. It will be remembered that it follows two rather distinct lines: (1) breeding experiments, with the hope of producing a rust-resistant type of asparagus; (2) fertilizer experiments, designed to throw light upon the special plant food requirements of the crop.

Breeding Experiments. — In the breeding work which is done at Concord the station is fortunate in enjoying the co-operation of the Bureau of Plant Industry of the United States Department of Agriculture. Mr. J. B. Norton of the Bureau has been assigned by Dr. B. T. Galloway to look after the asparagus breeding experiments. It is a pleasure to testify to the enthusiasm and faithful attention of Mr. Norton, who has not only most energetically prosecuted the breeding work, but has proved of much assistance in making observations and records on the fertilizer plots.

A very large number of crosses between selected plants have been made, and among these different crosses a few have resulted in offspring which seem to be almost absolutely immune to rust. These plants will be propagated and seed raised from them as rapidly as possible, with the object of producing stock for trial upon a more extended scale. If, however, the plants produced by some of the crosses continue to show the immunity exhibited by the seedlings, and if they have, as may be anticipated, the capacity to transmit their characteristics, a very gratifying forward step has certainly been made, and we may confidently anticipate complete success in attaining the end in view. At as early a date as possible, seed and young plants will be produced in quantities sufficient for trial by growers in different localities.

Fertilizer Experiments. — It remains true, as was stated to be the case in earlier reports concerning these experiments, that the growth and development of the crops, even upon the no fertilizer plots, owing to the very thorough preparation which the soil received, is still remarkably vigorous. Naturally, therefore, the varying fertilizer treatment does not as yet show the differences which may be confidently looked for. A few points, however, seem to be sufficiently well established to deserve mention.

The field contains 40 plots of one-twentieth acre each. The crop of 1910 was rather seriously injured by frost, but it was nevertheless fairly satisfactory as to quantity and quality. The past season was the fourth since the plants were set. The first cutting was made on April 23, the last on June 29. The total yield of all the plots was 9,020 pounds and 6 ounces.

Attention is called to the following conclusions, based upon results, as of possible interest: —

(1) The use of fertilizer made up of a combination of nitrate of soda, acid phosphate and muriate of potash, in addition to an application of manure at the rate of 10 tons per acre, has not materially increased the crop in whatever quantity applied.

(2) The use of nitrate of soda in addition to manure at the rate above named, in quantities ranging between the rate of from 311 pounds to 622 pounds per acre, has not increased the crop.

(3) The use of nitrate of soda in addition to a fairly liberal application of acid phosphate and muriate of potash has somewhat increased the crop, but a quantity in excess of 311 pounds has not resulted in further increase.

Chemical Work on Asparagus Roots. — It is a part of the plan of the experiments with fertilizers to study the effects of varying treatment upon the composition of the roots. This investigation on the chemical side is being carried on by Prof. F. W. Morse, who will in due time report fully upon the results of the analytical work. It was thought that a study of the reserve material stored in the roots in the autumn might offer results of especial interest and importance, and although the

investigation is not yet completed, this expectation has been largely realized. The special object in view in the first collection of roots made was to study the effect of the varying use of nitrogen in the form of nitrate of soda upon the reserve material in the roots in the autumn. The following points appear to have been well established by the analyses so far made: —

The amount of nitrogen in the roots in the fall: (1) is increased by application of nitrate of soda; (2) is greater where nitrate was used at the rate of 466 pounds per acre than where it was used at the rate of 311 pounds per acre; (3) is not greater where the nitrate of soda was used at the rate of 622 pounds per acre than where it was used at the rate of 466 pounds per acre.

It is believed, although this has not yet been proved, that the crop of the following season must bear a rather close relation to the amount of reserve material in the roots in the fall. If this be so, and if further investigation gives results in agreement with those already obtained, the conclusion that the use of nitrate of soda among our growers is not infrequently in excess of the most profitable quantity would appear to be justified. This conclusion should, however, for the present be regarded as tentative rather than fully established.

Cranberry Substations.

During the past year our work in the interest of cranberry growers has been put upon a much more satisfactory basis than heretofore, through a special appropriation by the Legislature to provide for the work. The amount of this appropriation was $15,000. A bog containing about 12 acres, lying near Spectacle Pond in East Wareham, with a small amount of adjoining upland, two small buildings and a powerful gasoline engine and pump, were purchased for $12,600. A building to contain screen and storage rooms, living and office rooms for an assistant, and a small laboratory will be erected early this year at a cost of about $2,000. The balance of the appropriation will be used for the purchase of additional upland to provide readier access to the building above referred to, in the making of needed

improvements in the pumping machinery and in preparations for experiments.

The cranberry bog purchased is planted with Early Black and the Howe varieties. It lies a little above the usual level of the water in Spectacle Pond, the lift required to flood it usually varying between about 3 and 4 feet. The capacity of the power and pumping machinery is such that the bog can be completely flooded in about six hours. The area of Spectacle Pond is nearly 100 acres, and the supply of water is constant and abundant. Being a "great pond" the waters are under State control. Only one other bog, and that a relatively small one, draws water from the pond, so that there must always be water enough for any possible need for all kinds of experimental work. The bog when purchased was in exceptionally perfect condition. It is one which has the reputation of more than average fruitfulness. The crop last year, as was the case with most of the bogs in the cranberry districts of Massachusetts, was moderate, and the net revenue derived from it was small. It is, however, confidently anticipated that the product of the bog will, over a series of years, be sufficient to produce a considerable net income, which will be used in helping to meet the expenses connected with our experimental work. The crop of the past season brought $1,255 more than the costs of ordinary maintenance, harvesting, packing, etc. The net sum available towards the costs of experimental work, however, was substantially $100 less than this, that being the amount which we were compelled to pay for taxes, since the bog had not been the property of the Commonwealth on the first of May.

It will be remembered that our cranberry work thus far has followed two principal lines of inquiry relating (1) to the fertilizer requirements of the crop; (2) to insects affecting it.

Fertilizer Experiments. — The fertilizer experiments begun four years ago in Red Brook bog at Waquoit have been continued. The bog, however, gave only a very small crop during the past season, — a result which we believe to have been due in large measure to the effects of frost. The variations in yield caused by uneven amount of frost damage were so great that it

was impossible to draw conclusions as to the specific effects of the different fertilizer combinations. The fertilizer experiments in the Red Brook bog at Waquoit will be continued during next year, but meanwhile similar experiments will be begun in the Spectacle Pond bog. It is believed that it will be best to discontinue the Waquoit experiments after next year, since they lie at such a distance from the station bog in Wareham as to make proper attention to the work somewhat difficult and expensive.

Insect Work. — Dr. Franklin has devoted himself with great enthusiasm and faithfulness to observations and studies on the insects having a relation either injurious or beneficial to the cranberry industry. He has accumulated a large amount of valuable data, but his work is not advanced to the point where publication seems called for.

Control Work.

Detailed reports concerning the various lines of control work carried on by the station, prepared by the chemists in charge, will be found in the later pages of this report.

Fertilizer Law. — We have found it impossible during the past few years to exercise an efficient control over the trade in fertilizers and to publish the reports without expending an amount exceeding the sum brought in by the analysis or license fees required by our law. The expenditure in 1909 exceeded the amount of the license fees to the amount of nearly $1,000. To provide for this excess expenditure by the use of other station funds seriously reduces the amount available for experimental work. Accordingly, the amount of analytical work in connection with the fertilizer control during the past year has been somewhat restricted, and the size of the bulletin giving the results has been reduced. These reductions, while for the time being necessary, are undesirable, and for this reason, as well as for other important reasons, it has been decided to ask for a revision of our fertilizer law. The preparation of the new draft has required a great deal of study and many conferences with parties affected by the law. The more important of the

changes which it provides are an increase in the analysis fee per fertilizer element from $5 to $8, and bringing the various grades of agricultural lime within its scope. The other changes which have been made have been designed to remedy defects from the standpoint of administration which the execution of the old law had disclosed, and to make it more definite and explicit on a number of rather important points. The fertilizer law at present in force requires us to publish the dealer's cash price and the percentage of difference between this price and the commercial valuation of the fertilizer. It is not proposed to retain this provision in the new law, as it is felt that it is on the whole likely to prove misleading to the farmer, almost inevitably unfair to dealers, and from no point of view apparently serves any important use.

Dairy Law. — Much time has been spent during the past year also in studying and rewriting the so-called dairy law. Besides various perfecting changes, the most important modification is to bring milk inspectors and the Babcock machinery and apparatus which they use within the scope of the law. There would seem to be equal reason that steps should be taken to insure accuracy of work on the results of which, if unfavorable, the milk dealer or farmer may be prosecuted for infringement of one of our State laws, as for bringing those testing milk and cream for determining its value within the scope of the law.

Feed Law. — The increasing number of feedstuffs in our markets, and the increased extent to which materials of complex character are purchased and used by our farmers, have greatly increased the amount of work required to exercise effective control over the trade in feedstuffs, and we find it to be impossible at the present time to properly execute the law and to publish the results of our inspection for the sum of money provided by the State legislative appropriation for the purpose. It will be necessary, therefore, in the near future, to ask for a revision of this law. The amount of the appropriation should be moderately increased to provide for the much greater amount of work now required than was necessary when the amount of

the appropriation was fixed some eight years ago. In the case of this law, also, practical experience in its execution has made it apparent that some perfecting amendments are necessary in order that it may operate smoothly and effectively.

Inspection of Apiaries.

The great desirability of the passage of a law providing for the inspection of apiaries, with a view to the eradication and control of contagious diseases of bees, was set forth at some length in my last annual report. It seems proper, therefore, in this report to refer to the fact that the Legislature of 1910 passed such an act. The execution of the law, however, was placed with the secretary of the State Board of Agriculture, but the experiment station and college are working in harmony with the secretary. He has named as inspector of apiaries the apiarist of the college and station, Dr. Burton N. Gates, whose appointment has already been referred to.

Buildings.

The new building for the departments of entomology and zoölogy has been completed during the year and has been occupied since September. It is a commodious, fireproof structure, costing $80,000, and paid for by special appropriation. It provides ample accommodations for the experimental work in entomology. The hothouse, a comparatively new and modern building used in connection with the old insectary for experimental work, has been moved on to new foundations and is connected with the new building.

The necessity for increased accommodations for the research chemical work of the station was pointed out in my last annual report, in which it was stated that plans for enlargement and modification of the old building for the purpose of securing the increased accommodations needed were under consideration. Mature study of the problem as to the best means of providing the needed room, in connection with more exact estimates of the cost of so enlarging and modifying our old laboratory as to meet the requirements, has led to the conclusion that it is unwise to make the relatively large expenditure required for such

enlargement and modification. It seems clear that the old building, however enlarged and improved, must still fail to be entirely adequate or satisfactory, and that therefore it is wiser at this time to make only the few absolutely necessary changes, involving relatively little expenditure, leaving full provision for our needs until such time as the State shall grant the money needed for a new building, which the growth of our work will render imperative in the very near future.

WM. P. BROOKS,

Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

OF FRED C. KENNEY, TREASURER OF THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

For the Year ending June 30, 1910.

The United States Appropriations, 1909–10.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1910, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$13,000 00
Cr.		
By salaries,	$13,184 81	$9,918 15
labor,	264 74	817 05
publications,	49 75	–
postage and stationery,	95 12	19 00
freight and express,	–	13 35
heat, light, water and power,	7 43	149 47
chemical supplies,	–	114 41
seeds, plants and sundry supplies,	250 19	496 08
fertilizers,	348 61	95 01
feeding stuffs,	406 48	–
library,	47 44	6 45
tools, implements and machinery,	–	–
furniture and fixtures,	117 00	328 50
scientific apparatus,	123 75	892 02
live stock,	48 00	–
traveling expenses,	56 68	105 51
contingent expenses,	–	–
building and land,	–	45 00
Total,	$15,000 00	$13,000 00

State Appropriation, 1909–10.

To balance on hand July 1, 1909,	$5,538 50	
Cash received from State Treasurer,	13,500 00	
from fertilizer fees,	5,970 00	
from individuals (cranberry contribution),	544 17	
from farm products,	3,208 73	
from miscellaneous sources,	6,387 84	
		$35,149 24
Cash paid for salaries,	$8,434 28	
for labor,	9,447 30	
for publications,	2,313 60	
for postage and stationery,	928 20	
for freight and express,	381 42	
for heat, light, water and supplies,	341 94	
for chemical supplies,	542 26	
for seeds, plants and sundry supplies,	2,348 15	
for fertilizers,	532 83	
for feeding stuffs,	1,468 03	
for library,	188 46	
for tools, implements and machinery,	26 70	
for furniture and fixtures,	240 95	
for scientific apparatus,	1,018 52	
for live stock,	80 38	
for traveling expenses,	2,299 51	
for buildings and land,	358 33	
Balance,	4,198 48	
		$35,149 24

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS.

The work in the department of agriculture during the past year has been of about the usual scope and extent. The problems which are being investigated are for the most part related to questions connected with the maintenance of fertility. Various questions connected with the selection, adaptation and methods of application of manures and fertilizers are being investigated. Most of our experiments have continued for a considerable number of years. Some indication is afforded of the amount of work in progress by the following statements. The number of field plots on the station grounds used in experiments the past year was 356. Our vegetation experiments have involved the use of 352 pots; while as a check upon the work in the open field, and as a method of throwing light upon a few special problems, 167 closed plots have been used.

No attempt will be made in this report to discuss the work in detail. Attention is called, however, to a few of the more striking results.

I. Comparisons of Different Materials as a Source of Nitrogen.

These experiments, which are carried on in Field A, were begun in 1890. The materials under comparison as sources of nitrogen are manure, one plot; nitrate of soda, two plots; dried blood, two plots; and sulfate of ammonia, three plots. Nitrate of soda and dried blood are used on one plot with muriate of potash; on the other with sulfate. The sulfate of ammonia is used on two plots in connection with muriate and on one in connection with sulfate of potash.

The different materials furnishing either nitrogen or potash are used on the several plots in such amounts as to furnish, respectively, equal quantities per plot of nitrogen and of potash; two of the three no-nitrogen plots which serve as checks receive potash in the form of muriate, the other in the form of sulfate, and all the plots in the field receive an equal liberal application of dissolved bone black as a source of phosphoric acid.

The crops grown in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans, potatoes, oats and peas, corn and clover for the last three years. The clover crop of the past year, as was true of the two preceding years, was considerably mixed with grass. The seed was sown early in August, 1909, and just previous to the sowing of the seed one-half of each of the plots in the field received a dressing of lime, at the rate of a ton and one-half to the acre. It was thought that such an application of lime would increase the efficiency of the sulfate of ammonia as a source of nitrogen, and to some extent this expectation appears to have been realized. The differences, however, between the limed and unlimed halves of the plots were relatively small, and the yields on the two halves were not separately determined.

The best crop of the past year was produced where nitrate of soda was used as a source of nitrogen; but the yields on dried blood and on sulfate of ammonia used in connection with sulfate of potash were not much inferior. On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen fertilizers and the no-nitrogen plots as measured by total yield during the past season was as follows: —

	Per Cent.
Nitrate of soda,	100.00
Dried blood,	93.73
Sulfate of ammonia,	95.53
Barnyard manure,	94.75
No nitrogen,	91.79

The relative standing of the different materials as indicated by total yield for the twenty-one years during which the experiment has continued is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.07
Dried blood,	92.38
Sulfate of ammonia,	86.87
No nitrogen,	71.96

On the basis of increase in crop as compared with the no-nitrogen plots, the average of the twenty-one years shows the following relative standing: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	78.85
Dried blood,	72.82
Sulfate of ammonia,	53.17

Nitrate of soda has given a much larger increase in crop than any of the other materials, and since the pound cost of the nitrogen of nitrate of soda is usually less than the pound cost in any other chemical fertilizer, the superior economy of its use is apparent.

II. Muriate compared with Sulfate of Potash.

Our long-continued experiments comparing muriate with high-grade sulfate as a source of potash have continued on Field B. It will be remembered that the two potash salts are used in such quantities as to furnish equal actual potash per acre. These experiments were begun in 1892. Five pairs of plots are under comparison. From 1892 to 1899 the potash salts were used in quantities (varying in different years, but always in equal amounts on the two members of pairs of plots) ranging from 350 to 400 pounds per acre. Since 1900 the quantity used has been uniform on all plots, and at the rate of 250 pounds per acre annually. Fine ground bone has been annually applied to each plot throughout the entire period of the experiment, and the rate of application is 600 pounds per acre. The season of 1910 is the nineteenth year of these experiments. The crops during that year were potatoes on one pair of plots, oats on one pair, and asparagus, rhubarb and blackberries. The rates of yield per acre on the different potash salts are shown in the following tables: —

	Rate per Acre (Pounds).		
	Asparagus.	Rhubarb.	Blackberries.
Muriate of potash,	5,604	24,587	2,661
Sulfate of potash,	4,143	25,856	2,821

	Rate per Acre.		
	Potatoes (Bushels).		Oat Hay (Pounds).
	Merchantable.	Small.	
Muriate of potash,	204.6	11.15	3,716
Sulfate of potash,	255.4	13.02	3,345

These figures call for but little comment, as they are in general in full agreement with results previously obtained. The asparagus gives a larger yield on the muriate of potash, which indicates the correctness of the ordinary practice of asparagus growers, who usually employ the muriate as a source of potash.

The rhubarb gives a slightly larger yield on the sulfate, and it was noticed during this year, as it has usually been in previous years, that the proportion of leaf to stalk is greater on the sulfate than on the muriate, the figures for this year on total weight of leaf being at the following rates per acre: —

	Pounds.
Muriate,	18,410
Sulfate,	20,560

No explanation can at present be offered for this difference.

The blackberries gave a larger yield on the sulfate, but the difference is not great. This, however, is in accordance with our observations in the case of most fruits, strawberries alone excepted, that sulfate of potash gives a better yield than muriate.

The difference in yield in potatoes on the two plots amounts to rather over 50 bushels. Such differences have been common in our experiments in earlier years, not only in this field, but in others as well. The difference in character of foliage of the potatoes on the two plots was strikingly evident from a period very early in their appearance above ground. The foliage of

the potatoes on the muriate of potash plots was lighter in color, it may be described as a pea green, while that on the sulfate of potash plot was of a much darker shade. An attempt has been made to demonstrate whether there is a difference in the amount of chlorophyl developed in the foliage produced, respectively, by the different potash salts, but the efforts so far made have not demonstrated such a difference. It is perfectly clear, however, that the muriate of potash as compared with sulfate is distinctly unfavorable to the production of starch in the tubers, the percentage of this constituent being almost invariably considerably higher than in the potatoes produced on the muriate.

The yield of oat hay on the muriate is considerably heavier than on the sulfate, and this result seems to be somewhat in harmony with results which we have previously obtained with corn, in the case of which grain the yield of stover on the muriate appears to be usually heavier than on the sulfate under otherwise similar conditions.

III. Nitrogen Fertilizers and Potash Salts for Garden Crops.

Three different nitrogen fertilizers, sulfate of ammonia, nitrate of soda and dried blood, and two potash salts, muriate and high-grade sulfate, each salt being used with each of the nitrogen fertilizers, are under comparison on Field C. In connection with the fertilizers named dissolved bone black was used in liberal amounts, which are the same on all plots. The comparison of these different fertilizers in this field was begun in 1891, but up to 1898 they were used alone. Since that time all plots have received annually a dressing of stable manure, at the rate of 30 tons per acre. The nitrogen fertilizers are used in such quantities as to furnish nitrogen at the rate of 60 pounds per acre, the potash salts in such quantities as to furnish 120 pounds of actual potash per acre, and the dissolved bone black was applied at the rate of 320 pounds per acre. The crops of the past year were asparagus, strawberries and onions.

Yields per Acre.

Plot.	Fertilizers.	Asparagus (Pounds).	Strawberries (Pounds).	Onions (Bushels).	
				Large.	Picklers.
0,	No fertilizer, . . .	3,378	7,012	304.4	53.5
1,	Muriate of potash, . Sulfate of ammonia,	3,984	7,661	173.1	39.3
2,	Muriate of potash, . Nitrate of soda, .	5,057	5,088	258.3	69.0
3,	Muriate of potash, . Dried blood, . .	5,052	6,697	259.2	40.2
4,	Sulfate of potash, . Sulfate of ammonia,	3,764	6,087	150.0	34.6
5,	Sulfate of potash, . Nitrate of soda, .	5,235	5,204	300.6	56.4
6,	Sulfate of potash, . Dried blood, . .	5,417	7,488	253.4	37.9

Attention is called in commenting upon these results to the fact that manure is used on Plot O at the same rate as on the other plots.

Asparagus. — Asparagus has long been recognized as a rank feeding crop, requiring liberal application of manure and fertilizers. It will be noticed that this is the only one of the three crops which appears to have been materially benefited by the use of the fertilizers. The crop on Plot O, on manure alone, is materially smaller than on either of the other two plots. Particular attention is called to the highly unfavorable effect of the combinations containing the sulfate of ammonia. The yields where this fertilizer was used are much below those produced where the other nitrogen fertilizers are employed, and not materially greater than where no fertilizer is used.

Strawberries. — It will be noted that in marked contrast with the results obtained with asparagus the yields of strawberries are highest on plots where sulfate of ammonia is used. A similar result has been obtained in earlier years. The highest yield of all has been produced where muriate of potash is used in connection with sulfate of ammonia, a combination which for

most crops has always seemed to be peculiarly unfavorable. Whether a similar result would be obtained in soils less highly enriched is at present a matter of uncertainty, but I desire to point out that in my judgment, based not only upon the yields of strawberries, which are not as large on the best of our plots as are obtained in good practice, but also upon the growth and development of the vines, flowers and fruit, the rate of use of manure and fertilizer in Field C is much too high for the best results. The vines have been over-rank, the fruit has set rather imperfectly and ripened poorly.

Onions. — Comparison of the yields on the different plots shows that none of the fertilizers used in connection with manure have apparently been beneficial. The combination containing sulfate of potash and nitrate of soda has done best; but the most significant point in connection with these results is the distinctly unfavorable effect of the combinations which contain sulfate of ammonia. The yield where this fertilizer is used is much below that on the other plots. The onions where this fertilizer is applied appear to stand practically still for a number of weeks after germination. They become distinctly unhealthy and many die. By midsummer the unfavorable influence disappears, the remaining plants take on a rank growth, the tops are heavy, the necks of the bulbs are thick, and comparatively few well-ripened bulbs are produced. It is probable that a heavy application of lime in connection with the sulfate of ammonia will in large measure, perhaps altogether, correct the faulty conditions which appear to be due to the use of this fertilizer.

IV. Relative Value of Different Potash Salts.

The experiments comparing different potash salts were begun in 1898. The following materials are under comparison: kainit, high-grade sulfate, low-grade sulfate, muriate, nitrate, carbonate and feldspar. There are 40 plots in all. Five have received no potash since the experiments began. Each potash salt is used on five different plots; in other words, there are five series of plots. The crop during the past year was hay (mixed timothy, redtop and clovers). The average yields on each treatment are shown in the following table: —

Average Yield per Acre (Pounds).

	Hay.	Rowen.
No potash, plots 1, 9, 17, 25, 33,	6,240	698
Kainit, plots 2, 10, 18, 26, 34,	6,656	966
High-grade sulfate, plots 3, 11, 19, 27, 35,	6,416	1,866
Low-grade sulfate, plots 4, 12, 20, 28, 36,	6,864	2,058
Muriate, plots 5, 13, 21, 29, 37,	6,976	1,752
Nitrate, plots 6, 14, 22, 30, 38,	7,784	1,916
Carbonate, plots 7, 15, 23, 31, 39,	6,280	1,984
Fine-ground feldspar, plots 8, 16, 24, 32, 40,	6,824	1,256
Average of all potash plots,	6,828	1,685

The various potash salts used are employed in such quantities as to furnish substantially equal actual potash to each plot. In the case of the feldspar, which is very fine ground, the quantity employed on Plot 8 furnishes the same amount of potash as that supplied by the different potash salts. Plot 16 receives the same amount as Plot 8, Plot 24 receives twice as much, Plot 32 three times as much, and Plot 40 four times as much. Particular attention is called to the fact that up to and including 1908 the plots now receiving feldspar had been annually receiving a potash salt which had given results indicating a high degree of availability. It is believed that the crops on these plots are still deriving considerable benefit from the residual potash applied in the earlier years of the experiment.

The following points seem especially worthy of notice: —

(1) The average yield of hay on all the potash plots exceeds the average yield on the no-potash plots by only 600 pounds. The average yield of rowen on the potash plots exceeds the yield on the no-potash plots by about 1,000 pounds. These figures indicate that the grasses, timothy and redtop, which make up the bulk of the first crop, are not dependent in very high degree upon an application of potash, and the much larger increase in the yield of rowen on the potash plots is clearly to be attributed to the fact that clovers make up the greater part of the rowen.

(2) The kainit, while favorable to the grasses, such as timothy and redtop, and therefore giving a first crop nearly equal

to the average for the potash salts, is distinctly inferior to any of the materials supplying potash in its effects upon the rowen. This is undoubtedly due to the large proportion of chlorides which kainit contains.

(3) It will be noticed that the yield of rowen on muriate of potash is considerably less than on either of the sulfates, the nitrate or the carbonate. We have noticed in our experiments that the muriate almost always proves distinctly less favorable to clovers than the sulfates. On the other hand, this salt appears to be highly favorable to the timothy and redtop, as is indicated by the relatively high yield of hay.

(4) The yield of rowen is highest on the low-grade sulfate of potash, and there is a noticeable difference in its favor in the yield of hay also. It is possible that the magnesium contained in this salt is proving of value for the hay crops.

The most marked result of the substitution during the past few years of feldspar for the silicate of potash used in the earlier years of the experiment on Plots 8, 16, 24, 32 and 40 has been the rapid disappearance of clover from these plots. This fact indicates that the claim of the manufacturers that the potash of the feldspar has been rendered available by the treatment to which it has been subjected is not justified by the facts. After two years the clover has disappeared from these plots almost as completely as from the plots to which no potash has been applied throughout the entire period of the experiment.

V. Comparison of Different Phosphates.

Ten of the leading materials which may be used as a source of phosphoric acid have been under comparison in one of our fields since 1897. The different materials are applied to the separate plots in such quantities as to furnish equal amounts of actual phosphoric acid to each. There are three check plots to which no phosphate whatever has been applied during the entire period of the experiment. All the plots receive annually equal and liberal quantities of materials supplying nitrogen and potash in highly available forms. The field has been used for a large variety of crops, the succession having been as follows: corn, cabbages, corn, oats and Hungarian grass (followed by

rye plowed under), onions, onions, cabbages, corn, mixed grass and clover three years, cabbages and soy beans. The crop this year was potatoes. The results are shown in the following table: —

Comparison of Phosphates.

Plot.	Fertilizer.	Yield Merchantable Potatoes per Plot (Pounds).	Yield per Plot (Pounds).		Yield Merchantable Potatoes per Acre (Bushels).	Loss or Gain per Acre (Bushels).
			Small.	Rotten.		
1,	No phosphate,	2,148	94	6	286.4	-
2,	Arkansas rock phosphate,	2,170	89	12	289.3	+40.9
3,	South Carolina rock,	1,986	53	23½	264.8	+16.4
4,	Florida soft rock,	1,761	107	24	234.8	—13.6
5,	Phosphatic slag,	1,841	76	18	245.5	—2.9
6,	Tennessee phosphate,	1,773	109	34	236.4	—12.0
7,	No phosphate,	1,831	53	36½	244.1	-
8,	Dissolved bone black,	1,859	90	12½	247.9	—0.5
9,	Raw bone meal,	1,941	140	12	258.8	+10.4
10,	Dissolved bone meal,	1,982	121	15	264.3	+15.9
11,	Steamed bone meal,	1,964	101	11½	261.9	+13.5
12,	Acid phosphate,	1,929	120	9½	257.2	+8.8
13,	No phosphate,	1,610	107	11½	214.7	-

The yield, as will be seen, was good on all plots. The average on the three check plots is 244.8 bushels of merchantable potatoes per acre. It will be noticed that the only one of the phosphates used which has given any very considerable increase in merchantable potatoes is the Arkansas rock phosphate, but I am convinced that the superiority of this phosphate is more apparent than real. The field declines somewhat in fertility from Plot 1 to Plot 13. It will be noticed that Plot 1 without phosphate gives a yield of merchantable tubers larger than any of the phosphate plots, with the exception of two, and that the crop on two is practically the same in amount as on one. The superior yield on these two plots is in my judgment merely a consequence of the fact that the soil texture in that part of the field is more favorable to the crop. The conclusions to which I would call particular attention may be stated as follows: —

(1) The potato would appear to be a crop relatively inde-

pendent of a supply of immediately available phosphoric acid. The result with potatoes offers a striking contrast to the result obtained in 1908 with cabbages, with which the crop on some of the best phosphate plots was more than six times greater than that produced on the no-phosphate plots.

(2) Although the phosphate used affected the total yield but little, it was noticed that during the first few weeks of their growth the vines on the plots to which the more available phosphates had been applied (phosphatic slag, dissolved bone black, dissolved bone meal and acid phosphate), made a much more rapid growth than on the other plots. The use of a little phosphoric acid, therefore, in highly available form, seems likely to prove a distinct advantage by pushing the crop more rapidly forward, so that it may better resist attacks of insects or unfavorable conditions which may occur later. It seems likely, further, that where the crop is cultivated for an early market the use of moderate amounts of highly available phosphoric acid may prove beneficial.

(3) The potatoes produced on the plot to which phosphatic slag has been annually applied for so many years were very scabby, although the seed planted was treated with formalin, as was that planted on the other plots also. So serious was this trouble that the market value of the crop was very greatly reduced, and the conclusion appears justified that a free use of phosphatic slag in the same season that land is to be planted with potatoes must in general prove highly undesirable. Slag meal is a strongly alkaline fertilizer, and this is undoubtedly the cause of the very scabby crop produced, since the scab fungus is known to be most troublesome in soils which are alkaline.

VI. Manure Alone compared with Manure and Sulfate of Potash.

This experiment, which occupies what is known as the south corn acre, has been in progress since 1890. The field is divided into four plots of one-fourth acre each. Good barnyard manure from milch cows, at the rate of 6 cords per acre, has been applied annually, with the exception of those years when it was

feared so doing would cause the newly seeded grass and clover to lodge, to two of these plots. Manure at the rate of 3 cords per acre, together with high-grade sulfate of potash at the rate of 160 pounds per acre, was applied to the other two plots from 1890 to 1895. Since the latter date the manure has been applied to these plots at the rate of 4 cords per acre in connection with 160 pounds of high-grade sulfate of potash, and whenever, for the reasons above stated, the application of manure has been omitted from the other two plots, both the manure and the potash have been withheld from these plots. The plan of cropping this field for the last twelve years has been corn and hay in rotation in periods of two years for each. During the past season the crop on this field has been hay, and the average yields per acre have been as follows: —

	Pounds.
Manure alone: —	
Hay,	4,480
Rowen,	1,050
Manure and potash: —	
Hay,	4,400
Rowen,	940

The rowen crop of the past season was very small, owing to the marked deficiency in rainfall. The corn crops raised in this field throughout the entire period of the experiment have been very nearly equal under the differing manurial treatments. The hay crops have usually been somewhat larger with the manure alone. The difference during the past season is considerably less than the average.

VII. Average Corn Fertilizer compared with Fertilizer Richer in Potash.

These experiments occupy what is known as the north corn acre. They have been in progress since 1891. This field, like the south corn acre, is divided into four plots of one-fourth acre each. Two of the plots receive a mixture furnishing nitrogen, phosphoric acid and potash in the same proportions in which they are contained in the average corn fertilizers offered in our markets. The other two plots annually receive an ap-

plication of a home-made mixture, containing much less phosphoric acid and more potash than is applied to the other plots. For the past fifteen years corn and hay, two years each, have regularly alternated. The crop of the past season was hay. Owing to the marked deficiency in rainfall already referred to the rowen crop was almost an absolute failure. The average yields were at the following rates per acre: —

	Pounds.
On the fertilizer rich in phosphoric acid and low in potash: —	
Hay,	3,260
Rowen,	330
On the fertilizer low in phosphoric acid and rich in potash: —	
Hay,	3,500
Rowen,	240

The results of the past season are similar to those which we have usually obtained, except that owing to the protracted drought the production of rowen on the plots receiving the larger proportion of potash is much lower than usual. In an average season the yield of rowen on these plots has invariably been greater than on the others.

VIII. South Acre Soil Test.

The crop raised in the south acre soil test which has continued in this field since 1889 was corn. The succession of crops grown on this field from the beginning of the experiment up to the present time has been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard (plowed in), corn, corn, grass and clover, grass and clover, corn, corn, corn, grass and clover, grass and clover, corn, oats and clover, buckwheat plowed under, corn. During the continuance of the experiment the field has been limed at the rate of a ton to the acre three times. The results of the past season with corn were entirely similar to those which have usually been obtained with that crop. Potash is still the dominant element. The average yield on the no-fertilizer plots, three in number, was at the rate of 4.05 bushels per acre. Muriate of potash alone increases the crop to nearly 23 bushels. Nitrate of soda alone gives a crop of 9 bushels. Dissolved bone black alone gives a yield at the rate of 4.21

bushels. The average increases due to the application of the different fertilizers (used in each case on four plots) were as follows: —

	Bushels per Acre.
Nitrate of soda,	3.2
Bone black,	6.8
Potash,	28.3

If we represent the average increase in grain due to the nitrate at 100, that due to the bone black is 212, that due to the potash 880.9. Similar figures for the stover are: —

	Pounds per Acre.
Nitrate,	186.2
Bone black,	406.5
Potash,	1,922.7

IX. North Acre Soil Test.

The soil test in this field was begun in 1890, and the crops grown since that year in the order of succession have been as follows: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and turnips, potatoes, onions, onions, onions, potatoes, grass and clover, grass and clover, corn, soy beans, grass and clover, grass and clover, grass and clover. The crop the past year was soy beans, for which the potash appears to be the dominant element. In this field one-half of each of the plots, which are long and narrow, has received three applications of lime, respectively, in 1899, 1904 and 1907. On the limed portion the increases due to the application of single fertilizer materials for the muriate of potash alone was 10.22 bushels per acre; for the nitrate of soda alone, 0.12 bushels; for the dissolved bone black alone, a loss of 4.45 bushels. The muriate of potash in combination with the other fertilizer elements did not give as large an increase in the crop as when used alone. The results will not be discussed in full at this time, but I may add that they are such as to suggest that the soda of the nitrate of soda is to a considerable extent either rendering the natural potash compounds of the soil available, or is itself to some extent taking the place of potash in the economy of the plant.

X. Top-dressing for Hay.

The experiments in the production of hay, by using in rotation as top-dressing barnyard manure, wood ashes and a mixture of bone meal and muriate of potash, have been continued during the past year in the nine-acre field where these experiments have been in progress since 1893. The average yield for the entire area this year was at the rate of 5,853 pounds per acre. The yields on the different materials used in top-dressing were at the following rates per acre: —

	Pounds.
Barnyard manure,	5,641
Fine ground bone and muriate of potash,	6,076
Wood ashes,	5,523

The crops this year were lighter than usual, as a consequence, without doubt, of the marked deficiency in rainfall already referred to. The average yields to date under the different systems of top-dressing have been at the following rates per acre: —

	Pounds.
Barnyard manure,	6,343
Wood ashes,	5,789
Fine ground bone and muriate of potash,	6,159

The average yield of the 9 acres from 1893 to 1910 inclusive has been at the rate of 6,134 pounds per acre. The rates of application per acre are: —

1.	Barnyard manure,	8 tons.
2.	Wood ashes,	1 ton.
3.	Ground bone,	600 pounds.
	Muriate of potash,	200 pounds.

XI. Winter v. Spring Application of Manure.

The experiments in progress for the purpose of testing the relative advantages of applying manure in the winter or in the spring were begun in 1899. There are five pairs of plots. In each pair the manure is applied to one plot some time during the winter. At the same time sufficient manure for the other and of the same quality is placed in a large heap, from which it

is spread in the spring. The field in which these experiments are in progress has a decided slope lengthwise of the plots, which lie side by side. The manure which is put on in the winter is applied to the various plots at different times. The crop of the past season was hay, mixed timothy, redtop and clovers. The supply of manure for use in the experiments this year was not as large as usual and Plot 4 was not top-dressed. The results on this plot, therefore, for this season illustrate simply the residual effects of the two systems of applying manure. It must be pointed out, also, that owing to the relatively slow accumulation of manure used in this experiment the quantity available for Plot 3 was not sufficient until the last of March, so that this year the manure was applied both to the north and south half of this plot on the same date, March 31. The results are shown by the following tables.

Yield per Acre (Pounds).

Plot.	North Half. Winter Application.		South Half. Spring Application.	
	Hay.	Rowen.	Hay.	Rowen.
1,	6,312	534	6,925	1,009
2,	6,252	1,049	6,826	950
3,	7,004	811	6,905	1,068
4,	5,857	534	6,114	752
5,	8,904	930	8,528	1,563

Relative Yields (Per Cent.).

Plot.	North Half. Winter Application.		South Half. Spring Application.	
	Hay.	Rowen.	Hay.	Rowen.
1,	100	100	109.7	188.9
2,	100	100	109.2	90.6
3,	100	100	98.6	131.6
4,	100	100	104.4	141.0
5,	100	100	95.8	168.1

Hay and Rowen (combined). — Average Yields.

Plot.	North Half. Winter Application.		South Half. Spring Application.	
	Per Acre (Pounds).	Per Cent.	Per Acre (Pounds).	Per Cent.
1, ...	6,846	100	7,934	115.9
2, ...	7,301	100	7,776	106.5
3, ...	7,815	100	7,973	102.0
4, ...	6,391	100	6,866	107.4
5, ...	9,834	100	10,091	102.7

REPORT OF THE CHEMIST.

JOSEPH B. LINDSEY.

This report is intended to give an outline of the work accomplished and in progress in the department of plant and animal chemistry for the year 1910.

1. Correspondence.

There have been substantially 5,000 letters sent out during the year ending Dec. 1, 1910, the estimate being made on the basis of stamps used. The correspondence divides itself into (*a*) answering letters of inquiry, (*b*) the execution of the fertilizer, feed and dairy laws, (*c*) the testing of cows, and (*d*) the ordering of supplies.

2. Numerical Summary of Work in the Chemical Laboratory.

From Dec. 1, 1909, to Dec. 1, 1910, there have been received and examined 101 samples of water, 459 of milk, 2,799 of cream, 151 of feed stuffs, 223 of fertilizers and fertilizer materials, 44 of soils and 48 miscellaneous. In connection with experiments made by this and other departments of the station, there have been examined 247 samples of milk, 115 of cattle feeds and 300 of agricultural plants. There have also been collected and examined 890 samples of fertilizer, in accordance with the requirements of the fertilizer law, and 1,055 samples of cattle feeds, in accordance with the requirements of the feed law. The total for the year has been 6,432. This summary does not include work done by the research division.

In addition to the above, 10 candidates have been examined

and given certificates to operate Babcock machines, and 4,047 pieces of Babcock glassware have been tested for accuracy of graduation, of which 41, or 1.01 per cent., were inaccurate.

3. Laboratory Work of the Research Section.

Messrs. Holland and Reed have continued work on the preparation of chemically pure insoluble fatty acids, and on the perfecting of methods for their quantitative determination. Investigations have also been continued relative to the cause of rancidity of fats, and upon the composition and preparation of chemically pure insecticides, particularly Paris green, arsenates of lead and arsenite of lime. Papers entitled "The Purification of Insoluble Fatty Acids" and "The Determination of Arsenic in Insecticides" are presented elsewhere in this report, and likewise in the "Journal of Industrial and Engineering Chemistry."

Mr. Morse has devoted his time to studying the effect of fertility on the chemical composition of asparagus roots, and presents a preliminary paper in this report and in the "Journal of the American Chemical Society" entitled "Soluble Carbohydrates of Asparagus Roots." Chemical analyses showed clearly that there was a marked increase in the total nitrogen in the roots, produced by the addition to the soil of different amounts of nitrate of soda. Low applications of nitrate gave an increase, medium still more, but high applications did not appear to be more effective than medium ones.

The carbohydrates in the reserve material of the roots consisted mainly of a soluble sugar, made up of fructose and glucose, the former decidedly in excess. Nitrogenous fertilizers apparently had no direct effect on the carbohydrates. In general the increase in protein accompanied a lower proportion of total carbohydrates, including fiber. Seventy-six samples of roots were gathered in November to repeat the nitrogen series and to extend the investigations to the effect of phosphorus and potassium.

Mr. Morse has also done some preliminary work in studying the character of the drainage waters from miniature cranberry bogs constructed under the direction of Director Brooks.

At intervals study has also been given to the chemistry of the soils on Field A, in hopes of ascertaining the cause or causes of clover sickness, but no definite results can be reported.

4. Research Work in Animal Nutrition.

Work is in progress to study the effect of lactic and butyric acids upon the digestibility of food. It has been shown that molasses is responsible for a decided digestion depression upon the foodstuffs with which it is fed. It being recognized that such material in the digestive tract is a large yielder of organic acids, it seemed at least possible that it is these acids which check the further action of the micro-organisms, and prevent their attacking the more difficultly digestible fiber, pentosans and gums.

A paper is presented elsewhere in this report attempting to show the protein requirements of dairy animals. Most dairy animals respond to increased amounts of protein over a protein minimum. By minimum is meant the amount required for maintenance plus that required in the milk. An excess of 25 per cent. over the minimum seems to give very satisfactory results, and is sufficient under most conditions.

Two experiments with dairy cows have been completed to note the comparative effects of corn meal, dried beet pulp and dried molasses beet pulp for milk production. Another experiment with corn meal versus ground oats has also been completed. The results have not been worked out.

The complete records of the station herd have been tabulated from 1896 through 1909, giving such data as food cost of milk production, dry and digestible matter required to produce definite amounts of milk, total solids and fat, relation of grain to roughage, etc. The food cost of 5 per cent. milk for 1909 was 3.3 cents per quart.

Tabulations.

There has been prepared and will be found elsewhere in this report the following tabulations: —

1. Analyses of all cattle feeds made in this laboratory through 1910.

2. Important ash constituents in cattle foods.
3. Composition of dairy products.
4. Digestion coefficients obtained from experiments made in the United States.
5. Composition of fertilizer materials and of natural and waste products.
6. Fertilizer constituents of fruit and garden crops.
7. Relative proportion of phosphoric acid, potash and nitrogen in fruit and garden crops.
8. Composition of some Massachusetts soils.

5. Report of the Fertilizer Section.

Mr. H. D. Haskins makes the following report: —

The principal work of this section has had to do with the execution of the fertilizer law of the State. Our experience this season indicated a very active demand for both chemicals and factory-mixed commercial fertilizers. There was a larger number of brands licensed than ever before. The inspection did not include the collection of as large a number of samples as during the previous year, although about the same number of brands were analyzed. It has been necessary to curtail somewhat, in order to keep as nearly as possible within the income derived from the fertilizer analysis fees. The expense of the inspection work has increased from year to year, and necessitates a larger income. It has also become evident that the old law requires many changes in order to make it applicable to present conditions. An attempt to improve the law is now under consideration.

Fertilizers licensed.

During the season of 1910 analysis fees have been paid by 83 manufacturers, importers and dealers, including the various branches of the American Agricultural Chemical Company, upon 465 distinct brands of fertilizer, including agricultural chemicals and by-products. Five more certificates of compliance have been issued, including 34 more brands than during 1909. They may be classed as follows: —

Complete fertilizers,	316
Fertilizers furnishing phosphoric acid and potash,	14
Ground bone, tankage and dry ground fish,	53
Chemicals and organic compounds furnishing nitrogen,	82
Total,	465

Fertilizers collected.

With but few exceptions, representative samples of every brand of fertilizer sold in the State have been secured. The collection work was in charge of Mr. James T. Howard, the regular inspector, assisted by Mr. A. B. Harris. As a general rule an effort has been made to collect samples of the same brand in different parts of the State, and to make one analysis of a composite sample made up of equal weights of the several samples. It is believed that this method will prove more satisfactory than when the results are based upon the analysis of a single sample. In all cases at least 10 per cent. of the number of bags found present were sampled; in cases where only a small amount of any particular brand was found in stock a larger percentage of the bags was sampled (often 50 to 100 per cent.), and in no case were less than five bags sampled without the fact being stated on the guarantee slip which is sent to the station laboratory with every brand of fertilizer sampled. One hundred and fourteen towns were visited, and samples of fertilizers were taken from 291 different agents. Eight hundred and ninety samples were drawn, representing 487 distinct brands. Some of the brands represent private formulas which farmers have had manufactured for their own use. The analyses of such brands were published in the bulletin in a table by themselves.

Fertilizers analyzed.

A total of 612 analyses was made in connection with the inspection of 1910. They may be grouped as follows: —

Complete fertilizers,	418
Fertilizers furnishing potash and phosphoric acid, such as ashes, superphosphates and potash,	21
Ground bones, tankage and fish,	71
Nitrogen compounds,	50
Potash compounds,	32
Phosphoric acid compounds,	20
Total,	612

The analyses were made in accordance with methods adopted by the Association of Official Agricultural Chemists. The analysis of a composite sample was made whenever possible, and in instances where such an analysis has shown a brand to be seriously deficient in one or more elements, a new portion was drawn from each original sample collected and a separate analysis made. This was done to determine whether the shortage was confined to one sample or whether it was general in case of that particular brand.

Twelve samples of lava fertilizer, so called, were analyzed. Although these materials have not been offered for sale in Massachusetts, considerable literature concerning them has been circulated, and it was thought best to have representative samples examined and the results published.

Thirty-two more analyses were made than during the previous year.

Trade Values of Fertilizing Ingredients.

The following table of trade values of fertilizer ingredients was used. It was adopted by the experiment stations of New England, New Jersey and New York at a meeting held in March, 1910. For purposes of comparison the 1909 schedule is also given.

	Cents per Pound.	
	1909.	1910.
Nitrogen: —		
In ammonia salts,	17	16
In nitrates,	16½	16
Organic nitrogen in dry and fine ground fish, meat, blood, and in high-grade mixed fertilizers,	19	20
Organic nitrogen in fine[1] bone and tankage,	19	20
Organic nitrogen in coarse[1] bone and tankage,	14	15
Phosphoric acid: —		
Soluble in water,	4	4½
Soluble in neutral citrate of ammonia solution (reverted phosphoric acid),[2]	3½	4
In fine[1] bone and tankage,	3½	4
In coarse[1] bone and tankage,	3	3½
In cottonseed meal, linseed meal, castor pomace and ashes,	3	3½
Insoluble in neutral citrate of ammonia solution (in mixed fertilizers),	2	2
Potash: —		
As sulfate, free from chlorides,	5	5
As muriate (chlorides),	4¼	4¼
As carbonate,	8	8

[1] Fine and medium bone and tankage are separated by a sieve having circular openings one-fiftieth of an inch in diameter. Valuations of these materials are based upon degree of fineness as well as upon composition.

[2] Dissolved by a neutral solution of ammonium citrate; specific gravity 1.09 in accordance with method adopted by the Association of Official Agricultural Chemists.

These trade values will be found to correspond fairly with the average wholesale quotations of chemicals and raw materials as found in trade publications for the six months preceding March 1, plus about 20 per cent. They represent the average pound cost for cash at retail of the various ingredients as furnished by standard unmixed chemicals and raw materials in large markets in New England and New York for the six months preceding March 1, 1910. The cost of the mineral forms of nitrogen (nitrate of soda and sulfate of ammonia) has been somewhat lower than for the previous year, which has led to a more general use of these forms of nitrogen. Nitrogen from organic sources has been a cent higher than for the season of 1909. The cost of phosphoric acid was one-half cent higher than for the previous season. There was no material change in the cost of the various forms of potash.

Summary of Analyses as compared with Guarantees of Licensed Complete Fertilizers.

Manufacturers.	Number of Brands Analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
W. H. Abbott,	3	1	3	1	1	–
American Agricultural Chemical Company,	78	55	75	19	3	–
Armour Fertilizer Works,	11	11	11	–	–	–
Baltimore Pulverizing Company,	4	–	2	4	–	–
Beach Soap Company,	5	3	5	2	–	–
Berkshire Fertilizer Company,	8	6	8	2	–	–
Bonora Chemical Company,	1	–	1	1	–	–
Bowker Fertilizer Company,	30	21	27	7	2	–
Joseph Breck & Sons Corporation,	3	1	3	2	–	–
Buffalo Fertilizer Company,	8	1	6	6	1	–
Coe-Mortimer Company,	13	6	10	3	3	1
Eastern Chemical Company,	1	1	1	–	–	–
Essex Fertilizer Company,	12	4	10	5	3	–
R. & J. Farquhar & Co.,	3	1	3	2	–	–
The Green Mountain Plant Food Company,	1	1	1	–	–	–

Summary of Analyses as compared with Guarantees of Licensed Complete Fertilizers — Con.

Manufacturers.	Number of Brands Analyzed.	Number with All Three Elements equal to Guarantee.	Number equal to Guarantee in Commercial Value.	Number with One Element below Guarantee.	Number with Two Elements below Guarantee.	Number with Three Elements below Guarantee.
C. W. Hastings,	1	–	1	1	–	–
Lister's Agricultural Chemical Works,	6	3	6	3	–	–
James E. McGovern,	1	–	1	1	–	–
Mapes' Formula and Peruvian Guano Company,	17	6	17	9	2	–
National Fertilizer Company,	14	8	12	3	3	–
New England Fertilizer Company,	6	3	5	2	–	1
Olds & Whipple,	6	4	6	1	1	–
Parmenter & Polsey Fertilizer Company,	8	1	7	4	3	–
R. T. Prentiss,	4	–	1	2	1	1
Pulverized Manure Company,	2	1	2	–	1	–
W. W. Rawson & Co.,	1	1	1	–	–	–
Rogers Manufacturing Company,	9	3	9	5	1	–
Rogers & Hubbard Company,	8	6	8	2	–	–
Ross Bros. Company,	3	2	3	1	–	–
N. Roy & Son,	1	1	1	–	–	–
Sanderson Fertilizer and Chemical Company,	6	5	6	–	1	–
M. L. Shoemaker & Co., Ltd.,	1	1	1	–	–	–
Swifts' Lowell Fertilizer Company,	17	4	15	9	2	2
W. G. Todd,	1	1	1	–	–	–
Whitman & Pratt Rendering Company,	5	–	5	4	1	–
Wilcox Fertilizer Works,	6	5	6	1	–	–
A. H. Wood & Co.,	3	–	3	2	1	–

The above table shows that 306 distinct brands of licensed complete fertilizers have been collected and analyzed.

That 140 brands (45.75 per cent. of the whole number analyzed) fell below the manufacturer's guarantee in one or more elements.

That 104 brands were deficient in one element.

That 30 brands were deficient in two elements.

That 6 brands were deficient in all three elements.

That 24 out of the 306 brands (7.85 per cent. of the whole number) showed a commercial shortage; that is, they did not show the amount and value of the plant food as expressed by the lower guarantee, although the values of any overruns were used to offset shortages.

The deficiencies were divided as follows: —

60 brands were found deficient in nitrogen.
80 brands were found deficient in available phosphoric acid.
71 brands were found deficient in potash.

When the data furnished by the above summary are compared with those of previous years, it is clear that greater care has been exercised on the part of the manufacturers, the guarantees being more generally maintained.

More brands were deficient in potash than during the previous year, a fact which may be due to temporary shortage in the supply of German potash salts in this country and correspondingly higher prices. These conditions were due to German legislation, which prevented the carrying out of contracts with German mine owners held by American fertilizer manufacturers except on payment of heavy production taxes.

Commercial Shortages.

The brands having a commercial shortage were much fewer in number than for 1909, and the amount or value of the shortages was much less, as may be seen from the following table: —

Commercial Shortages in Mixed Complete Fertilizers for 1910, as Compared with the Previous Year.

Commercial Shortages.	Number of Brands.	
	1910.	1909.
Over $4 per ton,	None	1
Between $3 and $4 per ton,	None	2
Between $2 and $3 per ton,	None	5
Between $1 and $2 per ton,	6	14
Under $1 but not less than 25 cents per ton,	18	35

There were a few brands showing rather serious deficiencies in some element of plant food, but which did not suffer a commercial shortage on account of an overrun of some other ingredient. Such brands, of course, may be seriously out of balance, and while not excusable, the manufacturer evidently had no intention to defraud.

Quality of Plant Food.

As a general rule the potash and phosphoric acid were furnished in the forms guaranteed.

It is hoped that methods of analysis may soon be perfected so that it will be possible to indicate the relative availability of the organic nitrogen in mixed fertilizers. The importance of this may, in a measure, be realized when it is remembered that nearly 45 per cent. of the nitrogen used in the complete fertilizers this year was derived from organic sources.

Grades of Fertilizer.

The following table shows the average comparative commercial values, the retail cash prices and the percentages of difference of the licensed complete fertilizers analyzed in Massachusetts during the season of 1909 and 1910, grouped according to commercial valuation. Those having a valuation of $18 or less per ton are called low grade; those having a valuation of between $18 and $24 are called medium grade; and those having a valuation of over $24 are called high grade.

	High Grade.		Medium Grade.		Low Grade.	
	1909.	1910.	1909.	1910.	1909.	1910.
Average ton valuation,	$27 63	$28 81	$20 69	$21 04	$15 32	$15 61
Average cash price,	$39 05	$38 40	$33 85	$33 51	$29 51	$27 80
Average money difference,	$11 42	$9 59	$13 16	$12 47	$14 19	$12 19
Percentage difference,	41.33	33.28	63.61	59.26	92.62	78.03

The percentage of difference column becomes a convenient method of comparing the commercial worth of fertilizers of the same grade and cost, and usually indicates fairly the most eco-

nomical fertilizer to purchase. It should never be interpreted as representing only the profit which the manufacturer makes on his fertilizer. It must include not only the profit, but all other expenses connected with the manufacture and delivery of the goods, such as grinding, mixing, bagging, transportation, agents' profits, long credits, interest and depreciation of factory plants.

Composition according to Grade. — The following table shows the average composition of the complete commercial fertilizers, according to grade, as sold in the Massachusetts markets during 1910: —

Grade.	Number of Brands.	Per Cent. of Whole Number.	Per Cent. of Nitrogen.	Per Cent. of Phosphoric Acid.			Per Cent. of Potash.	Pounds of Available Plant Food in 100 Pounds of Fertilizer.
				Soluble.	Reverted.	Available.		
High,	151	44.67	4.22	3.88	3.26	7.14	7.63	18.99
Medium,	120	35.50	2.65	4.86	2.81	7.67	5.06	15.38
Low,	67	19.83	1.77	4.55	2.46	7.01	3.06	11.84

A study of the above tables shows: —

1. That the percentage difference or percentage excess of the selling price over the valuation in the low-grade fertilizer is over twice what it is in the high-grade goods.

2. That with a 38 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes over 84 per cent. increase in commercial value.

3. The average high-grade fertilizers, with a 14.6 per cent. advance in price over the medium-grade goods, furnishes about 23 per cent. more plant food and about 37 per cent. increase in commercial value.

4. That with a 38 per cent. advance in price over the low-grade fertilizer, the high-grade furnishes more than 78 per cent. increase in available plant food.

5. The medium-grade goods cost about 20 per cent. more

than the low-grade goods and furnish over 34 per cent. greater commercial value.

6. That the per cent. of nitrogen and potash is very much higher in the high-grade goods than in the low or medium grade.

7. A ton of the average high-grade fertilizer furnishes about 49 pounds more nitrogen, 2½ pounds more available phosphoric acid and 91 pounds more actual potash than does a ton of the low-grade goods.

8. A ton of the average high-grade fertilizer furnishes about 31 pounds more nitrogen and about 51 pounds more potash than does a ton of the medium-grade goods.

Table showing the Comparative Pound Cost, in Cents, of Nitrogen, Potash and Phosphoric Acid in its Various Forms in the Three Grades of Fertilizer.

Element.	Low-grade Fertilizer.	Medium-grade Fertilizer.	High-grade Fertilizer.
Nitrogen,	35.62	31.85	26.66
Potash (as muriate),	7.57	6.77	5.67
Soluble phosphoric acid,	8.01	7.17	6.00
Reverted phosphoric acid,	7.12	6.37	5.33
Insoluble phosphoric acid,	3.56	3.19	2.67

This table emphasizes the marked increase in the cost of plant food wherever the low and medium grade fertilizers are purchased. It shows that nitrogen has cost 8.96 cents, available phosphoric acid about 2 cents and potash 1.9 cents per pound *more* in the average low-grade fertilizer than in the high-grade goods. It shows that nitrogen has cost 5.19 cents, the available phosphoric acid 1.11 cents and the potash 1.10 cents *more* per pound in the average medium-grade goods than in the average high-grade fertilizer. A comparison with the previous year shows that more high-grade brands have been sold this season than for 1909. There is, however, altogether too large a proportion of low and medium grade brands sold at present (55.33 per cent. of the whole). It is evident that too many purchasers select a fertilizer for its low cost, and without much

regard for the plant food which they are getting. The object in buying a fertilizer should be to get the largest amount of plant food in the proper form and proportion for the least money. The high-grade goods approach as near this ideal as is possible in case of factory-mixed fertilizers. It costs just as much to freight, cart and handle the low-grade fertilizers as it does the high grade. Nitrogen and potash in low-grade fertilizers cost from a third to a half more than if obtained from high-grade goods. *The farmer cannot afford to buy low-grade fertilizers.*

Unmixed Fertilizers.

MISCELLANEOUS SUBSTANCES. — *Ground Bone.* — Thirty-nine samples of ground bone have been inspected and analyzed. Nine were found deficient in phosphoric acid and 5 in nitrogen. None of the brands, however, showed a commercial shortage of 50 cents per ton. The average retail cash price for ground bone has been $31.13 per ton, the average valuation $29.75, and the percentage difference 4.64.

Ground Tankage. — Twelve samples of tankage have been analyzed. Four were found deficient in nitrogen and 4 in phosphoric acid. The average retail cash price per ton was $31.82, the average valuation per ton $31.28, and the percentage difference 1.73. Nitrogen in fine tankage has cost on the average 20.34 cents, while nitrogen in coarse tankage has cost 15.25 cents per pound. Two samples have shown a commercial shortage of over 50 cents per ton.

Dissolved Bone. — Two samples of dissolved bone have been analyzed and both were up to the guarantee placed upon them. The average retail cash price per ton has been $29.67, the average valuation $26.17, and the percentage difference 13.37.

Dry Ground Fish. — Twenty-three samples of dry ground fish have been examined, of which 5 were found deficient in nitrogen and 4 in phosphoric acid. The average retail cash price per ton was $39.65, the average valuation $38.89, and the percentage difference 1.95. Nitrogen from dry ground fish has cost on the average 20.39 cents per pound. Two brands have been analyzed, which show a commercial shortage of over 50 cents per ton.

Wood Ashes. — Thirteen samples of wood ashes have been analyzed, of which 1 was deficient in potash and 2 in phosphoric acid, although none of the samples showed a commercial shortage. Three samples put out by H. C. Green & Co., importers, were simply guaranteed "Pure wood ashes." The agent for three cars of these ashes, Ross Bros. Company, Worcester, Mass., stated that the ashes were of such poor quality that no charge would be made for them. Under present conditions of price and quality, the purchase of wood ashes is of questionable economy. They should never be bought without a guarantee of potash, phosphoric acid and lime.

Ground Rock. — The Farmhood Corporation of Boston, Mass., has offered a product called "Farmfood" which is unquestionably a ground mineral. It was guaranteed 2 per cent. phosphoric acid and 5 per cent. potash, both "in bond," meaning presumably associated with silica and not soluble. An analysis reveals the presence of 2.55 per cent. phosphoric acid, of which only .38 per cent. was available (dissolved by neutral citrate of ammonia). Only .56 per cent. of potash was found soluble in boiling water, and only .66 per cent. was found soluble in dilute hydrochloric acid. The commercial value of the product was $1.65 per ton, which would hardly pay cartage.

The New England Mineral Fertilizer Company [1] of Boston, Mass., has put out a product called "New England mineral fertilizer," which is apparently largely ground rock. The material was guaranteed .23 per cent. phosphoric acid and 1.50 per cent. potash. Our analysis showed .18 per cent. phosphoric acid, .10 per cent. water-soluble potash and .35 per cent. potash soluble in dilute hydrochloric acid. The plant food in a ton of this material is valued at 24 cents, although $17 is the advertised price in ton lots. Aside from the guarantee of potash and phosphoric acid, the firm makes a claim for a given percentage of soda, lime, magnesia, iron, sulfur, silica, chlorine and alumina. Although some of these elements are essential to the growth of plants, yet they are found in most soils in sufficient quantities to meet the needs of growing vegetation, so that they

[1] The New England Mineral Fertilizer Company, 19 Exchange Place, Boston, should not be confused with the New England Fertilizer Company, 40 North Market Street, Boston. The latter is an old company which has done business in Massachusetts for many years, and disclaims any connection with the New England Mineral Fertilizer Company.

have no particular significance in this connection. The extravagant claims made by the company for this "New England mineral fertilizer" are overdrawn, and border somewhat upon the ridiculous.

Nitrogen Compounds. — *Sulfate of Ammonia.* — Two samples of sulfate of ammonia have been analyzed and found well up to the guarantee. The average cost of the pound of nitrogen in this form has been 15.65 cents.

Nitrate of Soda. — Sixteen samples of nitrate of soda have been analyzed and only 1 was found deficient in nitrogen. The average cost of nitrogen per pound in this form has been 16.56 cents.

Dried Blood. — Three samples of this material were examined, 2 of the brands showing a considerable overrun and 1 a slight deficiency in nitrogen, the latter containing, however, considerable phosphoric acid. The average cost of nitrogen from blood has been 20.16 cents per pound.

Castor Pomace. — Six samples of castor pomace have been inspected and the guarantee was maintained in each instance. The average cost of nitrogen in this form has been 22.29 cents per pound.

Cottonseed Meal. — Nineteen samples of cottonseed meal used for fertilizer have been examined. These were licensed by 6 companies doing business in Massachusetts. Nitrogen from cottonseed meal has cost on the average 28.47 cents per pound. Seven out of the 19 samples analyzed showed a commercial shortage amounting to over 50 cents per ton.

Potash Compounds. — *Carbonate of Potash.* — Only 1 sample of carbonate of potash was analyzed during the season. It sold so that the pound cost of actual potash was 7.54 cents.

High-grade Sulfate of Potash. — Nine samples of high-grade sulfate of potash have been examined and the potash guarantee was maintained in every instance. The pound of actual potash in this form has cost, on the average, 4.64 cents.

Potash-magnesia Sulfate. — Seven samples of double sulfate of potash and magnesia have been examined, and all have been found well up to the guarantee. The pound cost of actual potash in this form has been 5.46 cents.

Muriate of Potash. — Eleven samples of muriate of potash

have been examined, and only 1 deficiency was found. The pound of actual potash as muriate or chloride has cost on the average 4.06 cents.

Kainit. — Two samples of kainit have been analyzed and found well up to the guarantee. The pound of actual potash from kainit has cost 4.21 cents.

Phosphoric Acid Compounds. — *Dissolved Bone Black.* — Three samples of dissolved bone black have been examined. Two of these were found somewhat low in available phosphoric acid, although only 1 showed a commercial shortage of over 50 cents per ton. The pound of available phosphoric acid from this source has cost, on the average, 5.91 cents.

Acid Phosphate. — Ten samples of acid phosphate have been examined, all but 3 being found well up to the minimum guarantee. No commercial shortages of over 50 cents per ton were noticed. The pound of available phosphoric acid from acid phosphate has cost 5.76 cents.

Basic Slag Phosphate. — Five samples have been analyzed, and the phosphoric acid ran low in 2 instances. There were no commercial shortages of over 50 cents per ton. The pound of available phosphoric acid (by Wagner's method) from basic slag has cost, on the average, 5.01 cents.

The complete results of the fertilizer inspection may be found in Bulletin 135.

Miscellaneous Work.

During the early part of the year some two months were devoted to the detailed mineral analysis of asparagus roots, in connection with fertilizer experiments carried on by the agricultural department. There has also been examined a number of cases of abnormal soils due to over-fertilization; such conditions are found particularly in greenhouse and tobacco soils, and in the latter case is confined to soils possessing an impervious subsoil, which will not permit of the free circulation of soluble saline materials.

In addition to the above work the fertilizer section has analyzed home mixtures, chemicals, by-products, soils, insecticides, etc., for farmers and farmers' organizations. We have insisted that all such material be taken according to furnished directions, which is more likely to insure representative sam-

ples, without which an analysis is of little value. In case of soils, but few complete detailed analyses have been made, and those only when abnormal conditions pointed to malnutrition or over-fertilization. In many cases tests were made to determine the relative amount of organic matter present and the acidity. Advice as to the use of fertilizer on any particular soil has been based more particularly upon the general character of the soil, previous manurial treatment, crop rotation, cultivation, and upon the crop to be grown.

In the analysis of by-products, refuse salts and materials used as fertilizers, the report has included the relative commercial value of the material and the best method of utilizing the same. During the year 300 miscellaneous analyses were made for citizens of the State and for the various departments of the experiment station. They may be grouped as follows: —

Fertilizers and by-products used as fertilizers,	223
Soils,	44
Miscellaneous materials,	33
Total,	300

As in the past, co-operative work was done in connection with the study of new methods of analysis for the Association of Official Agricultural Chemists. Much time and study were also given to perfecting a suitable method to determine the relative availability of nitrogen from organic sources in mixed fertilizers. Tests were also made on 80 brands of fertilizer selected from the 1910 official collection, to ascertain the efficiency of the improved alkaline-permanganate method in detecting the presence of low-grade organic ammoniates.

6. Report of the Feed and Dairy Section.

Mr. P. H. Smith reports: —

The Feed Law.

During the past year 1,055 samples of feedstuffs have been collected by Mr. James T. Howard, official inspector. These samples have been analyzed and are soon to be published, together with the necessary comments.

Analytical Work. — The analytical work has consisted of

protein and fat determinations on all samples, a fiber estimation in many cases and a microscopic examination when further information seemed desirable. A protein and fat guarantee are required by law. It is felt, however, that the protein and fiber content of a feedstuff are a much better index of its true value. Protein is the most valuable constituent, while fiber is of least value, and it is a fact that any feedstuff which contains a relatively high fiber percentage is quite apt to contain some inferior by-product. For this reason more fiber determinations have been made this year than ever before.

Compliance with the Law. — Fewer violations of the law have been noted than in previous years. Reputable manufacturers and dealers are coming to believe that the statute works no hardship in honest products. The time is not far distant when to neglect to brand a feedstuff will make the purchaser suspicious of its merits. In the future, violations of the feedstuffs law will be placed in our attorney's hands for settlement. In several instances this has already been done, and one case, where goods were not guaranteed, has been taken into court. The dealer entered a plea of guilty and the case was placed on file. It is not the intention of those having the enforcement of the law in charge to be overbearing in regard to this matter, but any law which is not enforced soon becomes inoperative. The benefits of the law are so obvious as to render it unwise to allow it to become a dead letter.

New Law. — At the time the present law was passed it was not possible to secure the requirement of a fiber guarantee. Since that time other States have enacted statutes which not only require a protein, fat and fiber guarantee on all feedstuffs, but in addition a statement of composition in the case of all compounded feeds. It is believed that Massachusetts should enact a law requiring every package of feedstuff sold or offered for sale to have attached the following information: —

1. The number of net pounds in the contents of the package.
2. Name, brand or trademark.
3. Name and principal address of the manufacturer or jobber responsible for placing the commodity on the market.
4. Its chemical analysis expressed in the following terms:

(*a*) minimum percentage of crude protein; (*b*) minimum percentage of crude fat; (*c*) maximum percentage of crude fiber.

5. If a compounded or mixed feed, the specific name of each ingredient therein.

A revision of the present statute is now under consideration which will include the above requirements, together with such changes as have from time to time suggested themselves.

Definitions. — At present there is more or less confusion between different States and different sections of the country in regard to names of commercial feedstuffs. A feedstuff which is recognized by one name in the west may be known by an entirely different name in the east. Again, manufacturers of low-grade goods often attach names which are misleading or at best mean nothing. The National Association of Feed Control Officials is considering uniform definitions for the different commercial feedstuffs. Such a group of definitions, if adopted by the feed control officials of the different States, will be of great benefit to the retailer and manufacturer.

Weight of Sacked Feeds. — There is a growing tendency on the part of some manufacturers to state the gross weight of a package instead of the weight of the contents. Others state both net and gross weights. The State law calls for the weight of the contents of the package. Purchasers who buy sacked feeds should see that they are getting full weight. The difference between gross and net weight will amount to about 1 pound per sack.

Co-operation. — It is a difficult matter to enforce the provisions of the feedstuffs law without the co-operation of both retailers and consumers. Consumers should refuse to buy goods which are not guaranteed, and retailers should refuse to handle goods which are received without a guarantee.

The Dairy Law.

The work required by this act is divided into three natural subdivisions: (1) the examination of candidates, (2) the testing of glassware, and (3) the inspection of machines.

(1) *Examination of Candidates.* — During the past year 10 candidates were examined for proficiency in the Babcock test.

All candidates are refused a certificate who fail to show proficiency in manipulation or who do not have a good working knowledge of the principles underlying the test. Eight candidates passed the examination at the first trial, and 2 certificates were withheld until further proficiency was acquired. The idea has been prevalent that the experiment station gives instruction in Babcock testing. Such is not the case; all candidates must, before presenting themselves for examination, have acquired a thorough knowledge of the test.

(2) *Examination of Glassware.* — During the past year 4,047 pieces of glassware were examined, of which 41 pieces, or 1.01 per cent., were inaccurate. This is the lowest percentage of inaccuracy found during the ten years that the law has been in force. Following is the summary of the work for the entire period: —

Year.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
Totals,	29,686	1,885	6.34[1]

The passage of this law has prevented 1,885 pieces of inaccurately graduated glassware, representing 6.34 per cent. of the entire number tested, from coming into use.

(3) *Inspection of Babcock Machines.* — Since the 1909 inspection 1 creamery has suspended operations. During the present inspection, recently completed, 28 places were visited, of which 15 were creameries, 12 milk depots and 1 a chemical laboratory. Ten of the creameries were co-operative and 5

[1] Average.

were proprietary. The 12 milk depots were in every case proprietary. Twenty-eight machines were examined, 2 of which were condemned, but on second inspection a few weeks later they were found to have been put in good condition. Those in use are 10 Facile, 6 Agos, 5 Electrical, 4 Grand Prize, 2 Wizard, 1 unknown. The glassware was, as a whole, clean, and with two exceptions Massachusetts tested. Where untested glassware was found in use, the provisions of the law were made plain, and it is not expected that there will be a repetition of the offense. Unless machines are set on firm foundation and the bearings kept well oiled, the required speed cannot be maintained economically, and machines will not give satisfaction. The Babcock machine should be as carefully looked after as the cream separator in order to give efficient service.

The creameries and milk depots where machines were inspected are as follows: —

1. *Creameries.*

LOCATION.	Name.	President or Manager.
1. Amherst,	Amherst,	W. A. Pease, manager.
2. Amherst,	Fort River,[1]	E. A. King, proprietor.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Brimfield,	Crystal Brook,	F. N. Lawrence, proprietor.
6. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
7. Egremont,	Egremont Co-operative,	E. A. Tyrrell, manager.
8. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
9. Heath,	Cold Spring,	F. E. Stetson, manager.
10. Hinsdale,	Hinsdale Creamery Company,	W. C. Solomon, proprietor.
11. Monterey,	Berkshire Hills Creamery,	F. A. Campbell, manager.
12. New Salem,	New Salem Co-operative,	W. A. Moore, president.
13. North Brookfield,	North Brookfield,	H. A. Richardson, proprietor.
14. Northfield,	Northfield Co-operative,	C. C. Stearns, manager.
15. Shelburne,	Shelburne Co-operative,	I. L. Barnard, manager.
16. Wyben Springs,	Wyben Springs Co-operative,	H. C. Kelso, manager.

[1] Pays by test. Testing done at Massachusetts Agricultural Experiment Station.

2. Milk Depots.

Location.	Name.	Manager.
1. Boston,	D. W. Whiting & Sons,	Geo. Whiting.
2. Boston,	H. P. Hood & Sons,	W. N. Brown.
3. Boston,	Boston Dairy Company,	W. A. Graustein.
4. Boston,	Boston Jersey Creamery,	T. P. Grant.
5. Boston,	Walker-Gordon Laboratory,	G. Franklin.
6. Boston,	Oak Grove Farm,	C. L. Alden.
7. Cambridge,	C. Brigham Company,	J. R. Blair.
8. Cheshire,	Ormsby Farms,	W. E. Penniman.
9. Dorchester,	Elm Farm Milk Company,	J. K. Knapp.
10. Sheffield,	Willow Brook Dairy,	L. C. Smith.
11. Southboro,	Deerfoot Farm Dairy,	S. H. Howes.
12. Springfield,	Tait Bros.,	W. A. Pease.
13. Springfield,	Emerson Laboratory,	H. C. Emerson.

Milk, Cream and Feeds sent for Free Examination.

During the past year the experiment station has analyzed a large number of samples of dairy products and feedstuffs sent for examination. Such work, where the results are of general interest, is a legitimate part of the station work. The station will not, however, act as a private chemist for manufacturers. Correspondence is solicited before samples are shipped, as in many cases the required information can be furnished without resorting to a chemical analysis, which will save shipping expenses to the applicant and the expense of a costly analysis to the experiment station. Upon application, full instructions for sampling and directions for shipping will be furnished, which will often obviate the necessity of sending another sample for analysis in place of one improperly taken.

Analysis of Drinking Water.

During the past year 101 samples of drinking water have been analyzed for residents of the State. The greater part of these were farm supplies where pollution was suspected. On reporting an analysis, suggestions are in all cases made as to

improving the supply when necessary. Parties wishing for water analysis should observe the following points: —

1. Application should be made for analysis.

2. A fee of $3 is charged for each analysis, payable with the application.

3. Only samples of water received in experiment station containers are analyzed (containers sent on application).

4. The experiment station does not make bacteriological examinations.

5. The experiment station does not undertake a mineral examination of waters for medicinal properties.

Miscellaneous Work.

In addition to the work already described, this section has conducted investigations and made other analyses as follows: —

1. It has co-operated with the Association of Official Agricultural Chemists in a study of the methods for the determination of acidity in gluten feeds.

2. It has co-operated with the officials of the New England Corn Exposition in making analysis of corn in connection with the awarding of prizes.

3. It has co-operated with the Bowker Fertilizer Company in making analyses of corn in connection with the awarding of prizes.

4. It has arranged and furnished exhibits and speakers in co-operation with the extension department for (*a*) the better farming special; (*b*) the better farming trolley special; (*c*) an exhibit for several of the Massachusetts fairs; (*d*) an exhibit for the New England Corn Show.

5. It has conducted an investigation in connection with cases of alleged arsenic poisoning of horses through eating sulfured oats, with negative results.

6. In connection with the experimental work of this and other departments of the experiment station, this section has made analyses of 247 samples of milk, 115 samples of cattle feeds and 300 samples of agricultural plants.

Testing of Pure-bred Cows.

The work of testing cows for the various cattle associations continues to increase. Such work is a tax upon the time of the head of this section, and, owing to the uncertainty of steady employment, it is often difficult to secure men to do the work. Two men are now employed permanently in connection with the Jersey, Guernsey and Ayrshire tests. The rules of the above associations require the presence of a supervisor once each month for two consecutive days at the farms where animals are on test. The milk yields noted by the supervisors at their monthly visits are used in checking the records reported by the owners to the several cattle clubs. The Babcock tests obtained at that time are likewise reported, and used as a basis for computing the butter fat yield for each month. Up to June 1, 1910, the supervisors were only required to spend one day in testing Guernsey cows. At the annual meeting of the American Guernsey Cattle Club, in May, 1910, the rules were changed so as to require a two-day monthly test. While this practically doubles the work for this breed, it is felt that a two-day basis is much more accurate in computing tests.

During the past year 1 214-day test and 44 yearly tests with Guernsey cows, 10 7-day and 88 yearly tests with Jersey cows, and a number of yearly tests with Ayrshire cows have been completed.

The Holstein-Friesian tests usually cover periods of from 7 to 30 days, and require the presence of a supervisor during the entire test. During the past year 16 different men have been employed at different times in conducting these tests, which give rather irregular employment during the winter months. On account of the uncertainty of the work such men are difficult to obtain, but thus far it has not been necessary for the experiment station to refuse an application. For the Holstein-Friesian association 112 7-day, 5 14-day, 11 30-day, and one semi-official year test have been completed.

There are now on test for yearly records 96 Jersey, 28 Guernsey and 8 Ayrshire cows.

REPORT OF THE BOTANIST.

G. E. STONE.

The routine and research work of the botanists and assistants for the past year followed similar lines to those of other years, except that perhaps the routine work has had a tendency to increase, leaving less time for research work. This has been remedied to a considerable extent, however, by the addition of Mr. Sumner C. Brooks as laboratory assistant. Mr. Brooks was graduated from the class of 1910, and his appointment as assistant relieves Mr. Chapman of much routine work and gives him time for research, for which he is well fitted. Miss J. V. Crocker has, as usual, been of much service in attending to the correspondence and records, and has given valuable assistance in the seed testing. Much assistance has, as formerly, been obtained from the undergraduate students, and Mr. E. A. Larrabee and Mr. Ray E. Torrey have devoted all their spare time to the department, and were employed during the whole summer vacation.

Diseases More or Less Common during the Year.

The season of 1910 opened unusually early, as is shown by the meteorological records and by the blossoming of trees, shrubs and flowers. The season was, on the whole, rather dry, and crops suffered to some extent from drought, a condition which was emphasized by the severe droughts of the two preceding years.

The peach leaf curl, which naturally follows a cold and rainy period, was quite common. Some frost occurred in May, and in some localities it was reported in June. The effects of this showed on asparagus, and frost blisters were common on apple foliage. An unusually large amount of apple foliage was sent in to this department for examination in early sum-

mer. This was affected not only with frost blisters, but considerable injury was caused by a mite, the effect being in many cases similar. An early outbreak of apple scab was also noticed on apple foliage.

Strawberries were of poor quality, and considerable rot of the fruit occurred, owing to excessive rainfall. The foliage of rock maples and oaks was affected to an unusual extent with Glœosporium. In many sections maples in general were affected with this fungus, causing a browning of the leaf and much defoliation, and many inquiries were received concerning this trouble.

Some of the diseases which were more common are as follows: hollyhock rust, sweet pea trouble, apple rust, hawthorne rust, quince rust, black rot of grapes, crown gall, sycamore blight, blossom end rot of tomatoes, pear blight and pear scab, corn smut and maple leaf spot (Rhytisma). Considerable interest is also manifest in the chestnut disease, which is becoming more noticeable in this State.

The following is a list of the less common diseases reported during the year: ash rust, bean rust, rose rust, pea mildew, rose mildew, currant Anthracnose, Anthracnose of melon, rust on strawberry leaves, cherry leaf spot (Cylindrosporium), potato rot, horse chestnut blight (Phyllosticta), apple scab, cane blight of raspberries (Coniothyrium), blackberry Anthracnose and cherry leaf blight (Cercospora). Besides these may be mentioned troubles with which no organisms are associated, namely, frost blisters, frost effect on asparagus, sun scald and sun scorch, malnutrition of cucumbers and aster yellows.

REPORT OF THE ENTOMOLOGIST.

H. T. FERNALD.

The year 1910 has been marked by numerous changes in this department. The resignation of Prof. C. H. Fernald in June, as station entomologist, marks the first change in the head of this portion of the station work since the department was established in 1888. The resignation, at the same time, of Mr. J. N. Summers from his connection with the station, and the poor health of the writer during the early part of the year, necessarily seriously affected the work accomplished, and the time taken in the fall by moving into new quarters has practically prevented anything besides routine work.

The development of a new line of investigation has been made possible by the appointment of Dr. B. N. Gates as station apiarist. Dr. Gates's work will be, at least for the present, entirely under the Adams fund.

Mr. Arthur I. Bourne has been appointed assistant in entomology, and is, in general, in charge of the correspondence and of considerable of the experimental work. His appointment will enable the head of the department to devote more time to the larger problems relating to insects in this State, both in general and in connection with Adams fund projects, than has heretofore been the case.

It has proved to be impossible to obtain an orchard near the station in which to continue the observations on the size and importance of the different broods of the codling moth. The movement for better fruit in Massachusetts has been nowhere more evident than in Amherst, and the results, though most desirable in general, have been disastrous for the continuation of this series of observations, which must now be discontinued. A long delay in moving the greenhouse to its new site, and in making it ready for use, has prevented taking up this year the

experiments on the resistance of muskmelons to fumigation. These can be resumed during 1911, however.

Further tests of methods of controlling wire worms attacking seed corn have been continued on Mr. Whitcomb's farm. The results of the tests already made were referred to in the last report, and were also published in the "Journal of Economic Entomology" for August, 1909. It was distinctly stated in the latter publication that these methods were still in the experimental stage, but that it seemed desirable to test them on a larger scale in different parts of the country. Several of the agricultural papers suggested this to their readers, and the reports received as to results varied from excellent to failure, by preventing germination. A few cases of failure have been investigated, and in every case so far appear to have been due to the use of coal tar instead of gas tar, or to giving the corn such a heavy coating of the tar as to, of itself, prevent germination. On the whole, the treatment can hardly be considered as having been fairly tested in all cases.

One objection to the method is that the seed must be treated first with tar and then with the Paris green. During the past season it has been attempted to avoid this, while obtaining equally good results, by the use of arsenate of lead. The particular brand used in these experiments was disparene, which comes in paste form. This was diluted till about as thick as paint. Then the corn was added and the whole thoroughly stirred. The corn was then spread out till dry.

Unfortunately, wire worms proved to be few in the fields where the treated corn was planted, so that the value of the test was restricted to a determination of the effect of the treatment on the germination of the seed. From this standpoint, however, it was a success, having no injurious effect whatever. Plans have already been made to continue this work another season, and fields badly infested with wire worms are to be made use of, so far as these can be found.

Dates of the hatching of the young of the oyster-shell scale, the scurfy scale and the pine-leaf scale have been continued as far as possible. The object of this has been stated in previous reports, and it need only be added here that the observations

should be continued for several years, if averages of value are to be obtained.

Nearly ten years ago a study of the Marguerite fly, a pest too familiar to many florists, was begun, but was soon dropped for lack of material. More having been obtained, this investigation has been resumed, and it is hoped that the entire life history of the fly may now be learned, together with effective methods for its control.

Observations on the distribution limits of insect pests in Massachusetts have been continued as opportunity has offered, and some interesting facts on this subject have been obtained. Work of this kind must, from its very nature, be fragmentary for a long time, and for years the gathering and preservation of the observations made are all which it will be possible to accomplish. As the time required for this is but a few moments per week, or even per month, however, the results are well worth the trouble.

Investigations on the importance of the Sphecidæ as parasites have been continued, and a number of additions to our knowledge of the group have resulted. The subject is a large one, however, and the amount of time available for this purpose has been much less than could be desired. Experiments with insecticides have been almost at a standstill from their entomological side, waiting for pure materials of known composition to be provided by the chemical department. Some of these have been satisfactorily obtained during the fall and the tests of them can be begun in the spring of 1911. The chemical results of this work will be reported upon by that department.

CHARLES ANTHONY GOESSMANN.

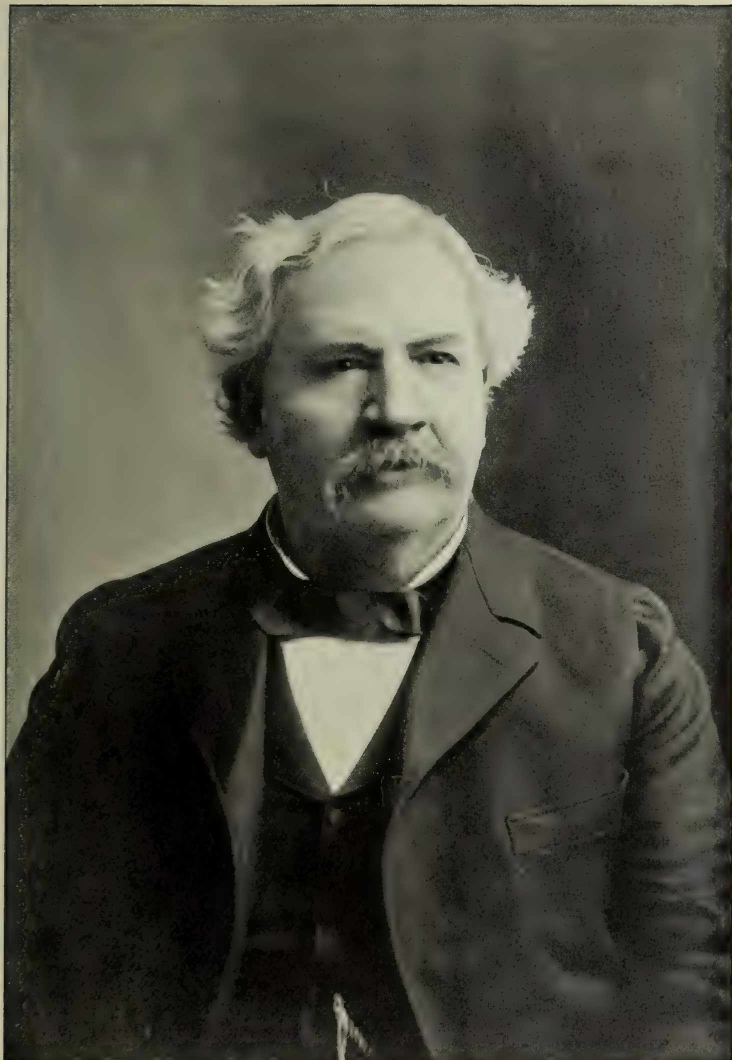
Charles Anthony Goessmann, chemist, investigator, teacher and philosopher, passed to the higher life Sept. 1, 1910.

Karl Anton Gössmann was born in Naumburg, in the Grand Duchy of Hesse, Germany, June 13, 1827. He was the son of Dr. Heinrich Gössmann, who was a fellow student of the noted chemist Frederich Wöhler. When the boy was seven or eight years of age the family moved to Fritzlar in Hesse and here young Gössmann spent his boyhood days. His father wished his son to become a pharmacist, and he received training in pharmacy previous to his becoming a university student. He entered the university of Göttingen in 1850, and studied chemistry, botany, physics, geology and mineralogy. He received the degree of Doctor of Philosophy in 1851 for a dissertation on the "Constituents of the Cantharides." Wöhler early recognized the ability and industry of the young chemist, and made him assistant in his laboratory, and upon the appointment of Limprecht to a professorship, Gössmann became a privatdocent and Wöhler's first assistant. He assumed charge of the chemical laboratory, and lectured on organic and technical chemistry as well as to students of pharmacy. His American students during the period were Chandler, Marsh, Joy, Nason, Caldwell and Pugh.

During his stay at Göttingen he received a number of flattering offers from other institutions, and made the acquaintance of Schönbein, the chemical physicist who discovered gun cotton and ozone; of Schrötter, noted for his researches in phosphorus; of A. W. von Hoffmann and of the celebrated French chemist Sainte Clair Deville.

In 1857 Gössmann left Göttingen on leave of absence, and visited the universities and a number of manufacturing establishments in Germany, Austria, France and England, and then journeyed to the United States upon invitation from Eastwich Brothers in order to become scientific director of their large sugar refineries. It was his intention eventually to return to Germany and teach technical chemistry, but he became so interested in the new country, and observed such a wide field of future usefulness for the technical chemist, that he decided to make the United States his permanent home.

After completing his work at Philadelphia he went to Cuba in order to study the methods of handling sugar then in vogue. On returning to the United States he was engaged as chemist by the Onondaga Salt Company of Syracuse, a position which he retained until 1869.



C. A. Goessmann

BORN JUNE 13, 1827. DIED SEPT. 1, 1910.

[Brief sketch of life, page 80.]

While in its employ, he visited and examined the salt springs in Canada, Michigan and Louisiana. During the latter part of this Syracuse period he spent a portion of each year as professor of chemistry and physics at the Rensselaer Polytechnic Institute at Troy, and he was invited to occupy the position permanently.

In 1868, at the earnest solicitation of his friend, the late Col. William S. Clark, he accepted the professorship of chemistry at the Massachusetts Agricultural College, and held it continuously until his retirement in June, 1907. He was placed at the head of the Massachusetts Experiment Station, a private enterprise started in 1878, and was instrumental in securing the establishment of the Massachusetts State Agricultural Experiment Station in 1882, being made its director and chemist, — positions which he held until it was merged with the Hatch Experiment Station by act of the Legislature in 1895.

Professor Goessmann served as chemist to the Massachusetts State Board of Agriculture from 1873 until his retirement, and for many years also acted as associate analyst of the Massachusetts State Board of Health. He became the first president of the Association of Official Agricultural Chemists, and was a charter member of the American Chemical Society, which he also served as president and vice-president. He was a member of the German society of naturalists and physicians, of the Physico-Medical Society of Erlangen University, a fellow of the American Association for the Advancement of Science, and a member of the Massachusetts Horticultural Society and of the Massachusetts Meteorological Society.

In 1889 Amherst College conferred upon him the degree of Doctor of Laws.

In this connection space forbids any extended reference to his work. Briefly it may be classified into four periods: —

1. The Göttingen Period of Seven Years, 1850–57.

In addition to his work as teacher in the university he found time to make and publish the results of twenty-five distinct investigations, all of which may be found in the "Annalen der Chemie u. Pharmacie." Among the most important of these papers may be mentioned the discovery of arachidic and hypogæic acids in the peanut oil, the constituents of the cantharides, the composition of cocoa oil and the constitution of leucine. This latter paper was considered of so much importance that it drew forth a letter of commendation from Wöhler to Dumas and secured for Gössmann membership in the Physico-Medical Society of the University of Erlangen, an honor which he highly prized.

2. The American Period of Eleven Years previous to the Massachusetts Agricultural College, 1858–69.

He made a number of contributions to the "American Journal of Science" on the chemistry of brine and salt, and while in the employ of the salt company at Syracuse devised a process for the removal of calcium and magnesium chlorides from salt which was of inestimable value to the salt industry of the United States. He also contributed papers to the "London Chemical News" on sugar refining.

3. The Massachusetts First Period, 1869–86.

During this period, in addition to teaching, Professor Goessmann made a study of the agricultural conditions in the State, was a frequent contributor to the agricultural press, and gave numerous lectures before the State Board of Agriculture.

His more prominent investigations may be briefly referred to under the following headings: —

(*a*) *Beets for Sugar, and Sugar Beets as an Agricultural Enterprise.* — He carried on investigations with the sugar beet both in the field and laboratory, and demonstrated the feasibility of growing beets for sugar in certain sections of Massachusetts, and concluded that, with the proper education of the farmer and capitalist, the production of sugar from the beet should prove a profitable American industry. (Reports of the Massachusetts Agricultural College, 1871, 1872, 1873, 1874, 1876.)

(*b*) *The Value of Early Amber Sorghum as a Sugar-producing Plant.* — His study of the plant as a possible source of sugar led him to conclude that "the presence of a large amount of grape sugar in all the later stages of growth . . . is a serious feature in the composition of the juice, impairing greatly the chances for a copious separation of the cane sugar by simple modes of treatment." *This prophesy has been literally fulfilled*, in spite of the later efforts to utilize this plant as a commercial source of sugar.

(*c*) *Reclamation of Salt Marshes.* — Goessmann made a thorough investigation of the condition of the marshes in southeastern Massachusetts, and embodied his results in a number of valuable papers before the Massachusetts State Board of Agriculture. His studies included the chemical conditions of the soils, and he recommended diking when necessary, suitable fertilizers and especially thorough drainage and cultivation. (Reports of the Massachusetts State Board of Agriculture, 1874, 1875, 1876.)

(*d*) *The Application of Chemistry to Fruit Culture.* — His studies were devoted particularly to the composition of the ash of different fruits, and to the influence of the various forms of mineral fertility upon yield and quality. He emphasized the need of a thorough study of the functions of the several mineral elements in plant growth, a

subject still calling for much careful investigation. He proved to his own satisfaction that muriate of potash promoted particularly the growth and improved the quality of fruit; and, further, that an increase of potash was accompanied by a corresponding decrease in lime and phosphorus. He called attention to the fact that the young branches of peach trees affected with "yellows" contained excessive amounts of lime and phosphoric acid, and that a judicious pruning, together with liberal applications of muriate of potash, restored the affected trees to a vigorous growth, which contained normal amounts of potash, lime and phosphoric acid. (Twenty-seventh and thirty-second reports of the Massachusetts State Board of Agriculture.)

(*e*) *The Chemical Composition of Different Varieties of Corn, and the Preservation of Corn in Silos.* — Goessmann gave considerable attention to the value of corn for cattle, and in a comprehensive paper published numerous analyses of different varieties of the entire corn plant, as well as of the stalks, ears and cobs. About 1880 attention was being given to the method of preserving corn in the silo, and the claim was made by Dr. J. M. Bailey and others that corn thus preserved (ensilage) did not suffer loss by the process, but was actually superior in feeding value to the original product. Goessmann in two admirable papers explained and discussed the principles of animal nutrition founded upon the researches of German investigators, showed the place of corn in the animal economy, pointed out the changes that took place during the process of fermentation, and made clear the relative merits of the dry and preserved corn. His statements concerning the relative value of silage and dry corn, made in 1880, hold true at the present time. (Reports of the Massachusetts State Board of Agriculture, 1879–80, 1880, 1881.)

(*f*) *The Inspection of Commercial Fertilizers.* — Goessmann was instrumental in securing the passage of a law authorizing the inspection of commercial fertilizers, which became operative Oct. 1, 1873, and as State Inspector of Fertilizers under the new law he made a preliminary report the same year. (Twenty-first report of the Massachusetts State Board of Agriculture.). It is believed that this was the first law enacted in the United States requiring an official inspection of fertilizers. He found many of the materials offered to be of uncertain composition, and to vary greatly in price; "these same articles cost the farmers . . . about one-half the amount more than they ought to". His work along this line from year to year corrected most of these abuses, and was unquestionably of great pecuniary value to the farmers of the State and nation.

4. *The Massachusetts Second Period, 1886–1907.*

The Massachusetts State Agricultural Experiment Station was established by act of the State Legislature, and Goessmann was made

director and chemist. The yearly grant of $5,000 was soon increased to $10,000, and in 1885–86 a new chemical laboratory was completed. He relinquished most of his college work, and devoted his energies to a thorough organization of the station.

The chief lines of work pursued by the station under his guidance are mentioned under the following general headings: —

1. The free analyses of fertilizers, refuse materials suitable for fertilizing purposes, coarse and concentrated feeds and drinking waters.

2. Experiments with dairy cows to test the relative feeding values of home-grown fodders and of commercial feedstuffs.

3. Feeding experiments with soiling crops, and the introduction and testing of new fodder crops.

4. Experiments with pigs to determine the rations best suited for pork production.

5. Feeding experiments with steers and sheep to determine the cost of beef and mutton, and to study the rations best suited for such purposes.

6. Field experiments to determine the nitrogen-acquiring power of the legumes.

7. Field experiments to study the best fertilizer combinations for market-garden crops.

8. Field experiments to ascertain the relative values of different forms of phosphoric acid.

9. Fertilizers best suited for permanent grass lands.

10. The effects of various forms of plant food in modifying the quality of the product.

11. Compilation of tables of analyses of fertilizers, cattle feeds, dairy products and fruits made at the station.

He devoted himself to the executive work of the station, and carefully supervised all of the experimental work as well. While not a rapid worker, he succeeded in accomplishing a great deal because of his steady and long-continued application. Since 1886 practically all of his papers were published in the annual reports of the experiment station.

After the merging of the State and Hatch stations, in 1895, advancing years made it necessary for him to relinquish many of his responsibilities. He continued, however, until his retirement to supervise the inspection of fertilizers and the general work in the fertilizer and soil laboratory.

Aside from his services as investigator and teacher, it is important to remember that he inspired in others a zeal for further study and accomplishment. There are to be found among his pupils presidents of colleges and schools of agriculture, directors of experiment stations, research and technical chemists, teachers, as well as workers in many lines of industry having a direct bearing upon agriculture.

Professor Goessmann possessed a wonderfully retentive memory, and being a great reader he was especially well informed on a wide variety of topics. He was a good conversationalist, and if interested in a subject poured forth a torrent of information, interspersed with opinions of his own. He had a genial disposition, a winning personality, and when he was amused his smile of appreciation was not soon to be forgotten. One did not need to be long associated with him to feel his influence for good and to realize that he was much more than an ordinary man. In fact, his very presence seemed to exhale a sort of spiritual essence which lifted one to a higher level of thought and feeling.

Goessmann was indeed a pioneer in the cause of agricultural investigation in the United States, or, as one of his students expressed it, he was a foundation builder. He was a leader, and pointed the way to a fuller understanding of the principles of science as applied to agriculture. Every experiment station worker, every tiller of the soil, and in fact every citizen in our great country, either directly or indirectly, has been benefited by this man who has recently passed into the Great Beyond.

J. B. LINDSEY.

STUDIES IN MILK SECRETION.

BY J. B. LINDSEY.

The Effect of Protein upon the Production and Composition of Milk.

Investigations and observations indicate that milk is not a simple fluid secreted directly by the blood, but a complex substance resulting from the activity of the milk cells. The cells and milk glands take from the blood and lymph vessels substances suited to their purposes, and by chemical and physiological processes convert them into a different substance, namely, milk. Milk, therefore, consists for the most part of reconstructed cell substance, and it is not possible, by any system of feeding, to produce very great modification in its composition. The composition of milk depends principally upon the breed and individuality of the cow, stage of lactation and development of the milk cells.

G. Kuhn,[1] M. Fleischer[1] and E. Wolff,[2] during the years 1868 to 1876, studied the additions to the different basal rations of increasing amounts of protein upon the composition of the milk, and noted only very slight variations. They observed that of all the milk components the percentage of fat was the most influenced by the food supply. N. J. Fjord and F. Friis,[3] as a result of experiments by the group method with 1,152 cows, concluded that the protein was practically without influence in varying the proportions of the several milk ingredients. W. H. Jordan[4] has conducted a number of trials, and failed to note any specific influence of the protein in

[1] Landw. Versuchsstationen 12 Bd., 1869; Journal für Landw., 1874.

[2] Die Versuchsstationen Hohenheim, Berlin, 1870; Résumé in Die Ernahrung der Landw. Nützthiere, E. Wolff, 1876.

[3] Beretning fra den Klg. Veterinær. og Landbohoiskole Lab. for landokonomiske Forsog. Kopenhagen, 1892; Résumé in Centralblatt f. Agricultur Chemie, 22 Jahrg., 1893. s. 604.

[4] Maine Experiment Station, reports for 1885-86, 1886-87; New York Experiment Station, Bulletin 197, 1906.

varying the proportion of the milk constituents. Armsby,[1] as well as Whitcher and Wood,[2] has drawn similar conclusions. Morgan *et als.* conclude from numerous investigations that protein is without specific influence in the formation of milk fat.[3] Kellner,[4] in summing up the results of numerous experiments, especially of German origin, says "in so far as it is possible by means of food to effect the action of the milk glands, the protein of the several food groups exerts a very pronounced influence. This influence is especially noticeable in increasing the *quantity* of the milk. Only after the long-continued feeding of a ration known to be deficient in protein does the water content of the milk increase, and the dry matter and fat show a noticeable decrease."

This station from time to time has conducted a number of experiments to observe the influence of different amounts of protein in increasing the quantity of milk, to note the protein requirements of dairy animals and also to study its influence in modifying the proportions of the several milk ingredients. Some of these results have been published in reports of the station. It is proposed to briefly summarize the results already given publicity, and to describe somewhat in detail our more recent observations.

Experiment I.[5] — *1895.*

This experiment was undertaken with six cows by the reversal method. The animals were from five to ten years of age, had all calved in the early autumn, and none had been served when the experiment began.

Weighing Animals. — The animals were weighed once before feeding and watering at the beginning and end of each half of the trial, and once each week during the continuance of the experiment. It would have been better to have weighed each animal for three consecutive days at the beginning and

[1] Wisconsin Experiment Station, reports for 1885–86, New Hampshire Experiment Station, Bulletin 90, pp. 12–14; Bulletin 18, p. 13.

[2] *Ibid.*

[3] Landw. Vers. Stat., 62 (1905), nos. 4, 5; pp. 251–286; Abs. Experiment Station Record Vol. 17, p. 286.

[4] Die Ernährung d. Landw. Nützthiere, erste Auflage, p.519; also, fünfte Auflage, p. 539.

[5] Ninth report of the Hatch Experiment Station, pp. 100–125.

end of the experiment; the weights, however, were probably sufficient to give an accurate *average weight* of each animal.

Sampling and Testing the Milk. — A composite sample of each cow's milk was made for five consecutive days, and preserved with bichromate of potash. Great care was used to secure representative samples. The total solids and fat were determined by approved gravimetric methods.

Dates of the Experiment.

Dates.	Days.	High Protein.	Low Protein.
Oct. 24 through Nov. 18, 1895, . . .	26	Cows I., IV., VI.	Cows II., III., V.
Nov. 28 through Dec. 23, 1895, . . .	26	Cows II., III., V.	Cows I., IV., VI.

At least a week elapsed after the animals were placed upon full rations before the experiment proper began.

Average Daily Rations fed to the Six Cows (Pounds).

Character of Ration.	Wheat Bran.	Chicago Gluten Meal.	Corn Meal.	Hay.	Sugar Beets.
High protein, ...	3	5.83	–	15.17	12
Low protein, ...	3	–	5.83	16.17	12

Each of the cows received 3 pounds of bran and 12 pounds of beets daily. One of the cows, Ada, received only 5 pounds of corn or gluten meal per day, while the others received each 6 pounds. The amount of hay fed differed slightly in the case of individual cows, depending upon their ability to utilize it. The hay was of good quality, containing 9.73 per cent. of crude protein; the bran 19.20 per cent.; the gluten meal 42.73 per cent., and the corn meal 11.36 per cent., all on a dry-matter basis.

It will be seen that the basal ration consisted of hay, beets and bran, and that the variable factor was the corn or gluten meal.

Average Weight of Animals and Average Digestible Nutrients in Daily Rations (Pounds).

Character of Ration.	Weight of Animal.	Digestible Nutrients.				Nutritive Ratio.
		Protein.	Fat.	Fiber and Extract Matter.	Total.	
High protein, ...	941	3.07	.59	10.23	14.06	1:3.86
Low protein, ...	938	1.46	.52	12.45	14.43	1:9.43

Three of the cows varied in weight from 800 to 900 pounds, and three others from 1,000 to 1,060 pounds. During the high-protein period the cows gained in total 101 pounds, and during the low-protein period there was a total loss of 64 pounds. The average weight of the herd during each of the two halves of the experiment was substantially the same.

The figures for digestible nutrients were secured from actual analysis of the feedstuffs used, together with average digestion coefficients, actual digestion tests not being made. The total digestible nutrients consumed was the same in case of each of the halves of the experiment, the difference being in the excess of digestible protein and the corresponding deficit of carbohydrates. The high-protein ration had evidently too narrow a ratio, and the low-protein ration too wide a ratio for the best results.

Protein Balance (Pounds).

Character of Ration.	Cows.	Protein digested.	Protein required for Maintenance.	Protein contained in Milk (N. x 6.25).	Protein Excess over Maintenance and Milk Requirements.
High protein, . . .	Ada, . .	69.16	14.56	20.31	34.29
	Una, . .	79.56	16.38	18.66	44.52
	Bessie, . .	81.12	15.60	26.03	39.49
	Beauty, .	84.24	18.98	22.28	42.98
	Red, . .	82.16	19.24	24.26	38.66
	Spot, . .	82.16	17.94	28.00	36.22
Low protein, . . .	Ada, . .	33.54	14.56	17.84	1.14
	Una, . .	36.40	16.12	17.84	2.44
	Bessie, . .	37.96	15.60	22 51	—.15
	Beauty, .	40.82	18.98	17.92	3.92
	Red, . .	39.00	18.72	22.08	—.1.80
	Spot, . .	39.00	18.20	20.72	.08
Total high, ...	–	478.40	102.70	139.54	236.16
Total low, ...	–	226.72	102.18	118.91	5.63
Average per cow, high, .	–	79.73	17.12	23.26	39.36
Average per cow, low, .	–	37.79	17.03	19.82	.94

[1] Calculated by allowing .7 of a pound digestible crude protein per day per 1,000 pounds live weight.

In this experiment the percentage of protein in the milk was not determined, and the average figures secured for the experiment immediately following were employed. Calculations show that in the high-protein period there was a surplus of nearly 100 (97.5) per cent. of digestible protein over that required for maintenance and milk production, while in the low-protein period the total digestible protein consumed and the amount required were about equal.

Influence of Protein on the Milk Yield.

Herd Results in Pounds.

Character of Ration.	Average Weight of Cow.	Yield of Milk.	Protein digested.	Protein required for Maintenance and Milk.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
High protein, . .	941	4,241.5	478.40	242.24	236.16	97.5
Low protein, . .	938	3,695.5	226.72	221.09	5.63	2.3

It is quite evident that the ration with the large excess of digestible protein exerted a marked influence on the milk-secreting organs, causing an increase of approximately 15 per cent. in the milk yield. The average daily milk product per cow during the high-protein period was 27.2 pounds, and during the low-protein period 23.7 pounds, and it therefore may be said that both rations produced a fair yield. The period was too short to note the effect of the larger amount of protein on the general condition of the animal; it is believed, however, that if such an amount had been fed for a long period of time, the result would have been over-stimulation, indigestion and a refusal to eat the large amount of gluten meal.

Effect of the Rations on the Composition of the Milk (Per Cent.).

Character of Ration.	Total Solids.	Fat.	Solids not Fat.
High protein, ...	13.67	4.51	9.16
Low protein, ...	13.45	4.28	9.17

Composite samples of each cow's milk were secured for five days of each week. These composites were averaged, and this average represented the composition of the milk of each cow for the period. The average percentage produced by each cow was multipled by the pounds of milk she produced, thus securing the weight of total solid matter and fat yield by each animal in the herd. These totals were added and the amount divided by the total amount of milk given by the herd, and the quotient represents the average percentage of total solids and of fat, as stated in the table.

The results indicate that during the low-protein period, the cows produced milk containing .23 per cent. less fat than in the period when the high protein was fed. The difference is not pronounced and may be considered within the limit of a reasonable experimental error.

Experiment II.[1]

This experiment immediately succeeded experiment I. and was conducted with the same cows, excepting that cow II. (Una) was replaced by Guernsey. The general plan of the experiment, methods of caring for the cows, feeding and sampling of milk were all identical with the preceding experiment.

Dates of the Experiment.

Dates.	Days.	High Protein.	Low Protein.
Jan. 27 through Feb. 16, 1896, . . .	21	Cows I., II., VI.	Cows III., IV., V.
Feb. 29 through March 20, 1896, . .	21	Cows III., IV., V.	Cows I., II., VI.

It will be seen that each period lasted twenty-one days, with a preliminary feeding of seven or more days.

Average Daily Rations fed to the Six Cows (Pounds).

Character of Ration.	Wheat Bran.	Chicago Gluten Meal.	Linseed Meal.	Corn Meal.	Hay.	Millet and Soy Bean Silage.
High protein, . .	2.83	3.00	1.92	–	10.33	28.33
Low protein, . .	1.92	–	–	5.83	10.33	28.33

[1] Ninth annual report of the Hatch Experiment Station, pp. 100–125.

The bran contained 18.87 per cent., the Chicago gluten 39.75 per cent., the old-process linseed meal 41.99 per cent. and the corn meal 11.36 per cent. of protein in dry matter. The silage was a mixture of barnyard millet and soy beans, the latter being quite well podded; it contained about 81 per cent. of water and 12 per cent. of protein in dry matter. Each animal received from 9 to 11 pounds of hay, 20 to 30 pounds of silage, during each half of the experiment. In the high-protein ration from 2 to 3 pounds of bran were fed, 3 pounds of gluten and 1.5 to 2 pounds of linseed meal. In the low-protein ration 1.5 to 2 pounds of bran were given and 5 to 6 pounds of corn meal. The above table shows the averages. The cows ate their rations clean in every case.

Average Weight of Animals and Average Digestible Nutrients fed daily (Pounds).

Character of Ration.	Weight of Animals.	Protein.	Fat.	Fiber and Extract Matter.	Total.	Nutritive Ratio.
High protein, . .	899	2.85	.65	9.96	13.46	1:4.04
Low protein, . .	900	1.45	.54	11.44	13.42	1:8.85

The individual weight of the individual cows varied from 763 to 1,004 pounds. The cows changed very slightly in weight during each half of the experiment.

The digestible nutrients were calculated from the analyses of the feed, with the aid of average digestion coefficients. The high-protein ration contained substantially twice as much digestible protein as the low-protein ration. The fat varied but slightly, and the difference in the amount of carbohydrate matter depended naturally upon the different amounts of protein fed. The total nutrients consumed in two rations were the same.

Protein Balance (Pounds).

Periods of Twenty-one Days.

Character of Ration.	Cows.	Protein digested.	Protein required for Maintenance.	Protein contained in Milk (N x 6.25).	Protein Excess over Maintenance and Milk Requirement.
High protein,	Ada,	50.61	11.21	15.42	23.98
	Guernsey,	60.61	12.60	19.52	28.49
	Bessie,	61.53	12.18	18.98	30.37
	Beauty,	62.58	14.41	16.22	31.95
	Red,	62.58	14.91	17.37	30.30
	Spot,	62.58	13.86	20.29	28.43
Low protein,	Ada,	25.20	11.34	12.83	1.03
	Guernsey,	31.50	12.30	16.36	2.84
	Bessie,	30.24	12.09	15.90	2.25
	Beauty,	31.29	14.07	15.08	2.14
	Red,	31.29	14.70	16.05	.54
	Spot,	32.55	13.84	16.65	2.06
Total high,	–	360.49	79.17	107.80	173.52
Total low,	–	182.07	78.34	92.87	10.86
Average per cow, high,	–	60.08	13.19	17.97	28.75
Average per cow, low,	–	30.34	13.06	15.48	1.81

Influence of Protein on Milk Yield.

Herd Results in Pounds.

Character of Ration.	Average Weight of Cows.	Yield of Milk.	Daily Yield of Milk per Cow.	Protein digested.	Protein required for Maintenance and in Milk.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
High protein,	899	3,261.0	25.82	360.49	186.97	173.52	92.8
Low protein,	900	2,877.0	22.73	182.02	171.21	10.86	5.1

It will be seen that on the high-protein ration the cows received 92.8 per cent. more digestible crude protein than was required for maintenance and for the milk produced, while in low-protein ration the excess was only 5 per cent., the amount digested and the amount fed being substantially equal.

The figures show that for a period of twenty-one days, while not changing in weight, the herd produced 13.3 per cent. more milk on the high-protein diet, showing very distinctly the influence of the excess of protein. This experiment exactly confirms the experiment immediately preceding.

Composition of the Herd Milk (Per Cent.).

Character of Ration.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Protein Equivalent.
High protein,	13.82	4.83	8.99	.526	3.28
Low protein,	14.10	5.02	9.08	.518	3.23

The samples were taken and averages secured in the same way as in the previous experiment. Here we have a direct reversal of the results, the low-protein ration showing a trifle higher average fat percentage than the high-protein ration. This may also be regarded as within the limit of error. The percentage of nitrogen in the milk produced during each half of the experiment is substantially the same, and this in spite of the fact that the low-protein ration contained but 1.45 pounds of digestible protein, and the high-protein ration 2.85 pounds.

Experiment III.[1]

This experiment was one of a series designed to study the effect of food stuffs upon the composition of milk and of butter fat. Only that portion of the experiment is here published which shows the influence of protein upon the yield and composition of the milk. It was planned on the group system, five cows composing each group. The first two periods of the experiment only are needed in this connection.

Duration of Experiment.

Periods.	Dates of Experiment.	Length in Weeks.
First period: both herds standard ration,	Nov. 17, through Dec. 7, 1900,	3
Second period: { Herd I., standard ration, Herd II., cottonseed ration, }	Jan. 5, through Feb. 8, 1901,	5

[1] See résumé in fourteenth report of the Hatch Experiment Station, pp. 162–168.

Average Daily Rations (Pounds).

First period: both herds, standard grain ration.

Herds.	Standard Grain Ration.	Cotton-seed Meal.	First-cut Hay.	Rowen.
Herd I.,	9	–	8–12	10
Herd II.,	9	–	8–12	10
Second period: Herd I., standard ration; Herd II., cottonseed ration.				
Herd I.,	9	–	8–12	10
Herd II.,	5	3	8–12	10

The standard ration consisted of 3 pounds of wheat bran, 5 pounds of ground oats and ½ pound each of cottonseed and gluten meals. The cottonseed meal contained some 9 per cent. of oil and 54.54 per cent. of protein in dry matter.

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

First period: both herds, standard grain ration.

Herds.	Dry Matter.	Protein.	Fiber and Extract Matter.	Fat.	Total.	Nutritive Ratio.
Herd I.,	26.15	2.44	12.84	.68	15.95	1:5.8
Herd II.,	26.97	2.49	13.25	.69	16.42	1:5.9
Second period: Herd I., standard grain ration; Herd II., cottonseed ration.						
Herd I.,	25.00	2.34	12.27	.66	15.27	1:5.8
Herd II.,	25.69	3.20	11.62	.73	15.55	1:4.1

The digestibility of the standard grain mixture was ascertained by actual experiment. Average coefficients were used for the other feeds. Both herds received substantially the same amounts of protein and total digestible nutrients in the first period. Each herd averaged in live weight about 950 pounds. In the first period the amount of digestible protein was ample to enable the cows to do good work. In the second period Herd II. received .86 of a pound more of digestible protein than did Herd I.

Total and Average Daily Yield of Milk (Pounds).

First period: both herds, standard grain ration.

Herds.	Total Herd Yield.	Average Daily Yield.
Herd I.,	2,332.5	22.2
Herd II.,	2,405.3	22.9
Second period: Herd I., standard ration; Herd II., cottonseed meal ration.		
Herd I.,	3,856.3	21.9
Herd II.,	3,898.1	22.2

In the first period Herd II. produced 3.1 per cent. more milk than Herd I., and in the second period 1 per cent. more. It would appear, therefore, that the amount of protein fed in the first period was ample, and that the increase given to Herd II. in the second period was not needed and did not increase the milk flow. In the first period Herd I. gained 6 pounds in live weight, and Herd II., 83 pounds. In the second period Herd I. lost 87 pounds, and Herd. II., 73 pounds.

Average Composition of the Herd Milk (Per Cent.).

First period: both herds, standard grain ration.

Herds.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Protein Equivalent.	Ash.
Herd I.,	14.15	5.00	9.15	.538	3.36	.73
Herd II.,	14.27	4.93	9.34	.546	3.41	.72
Second period: Herd I., standard ration; Herd II., cottonseed meal ration.						
Herd I.,	14.16	5.06	9.10	.550	3.44	.73
Herd II.,	14.30	4.98	9.32	.562	3.51	.71

The analyses for the first period represent the average of 3 separate samples, each covering a period of five days; those for the second period represent the average of 5 separate samples, each covering a period of five days. Each five-day composite represented the average composition of the herd milk for one week. The separate analysis of each cow's milk was not made.

In the first period the milk of the two herds showed itself to be practically identical in composition. In the second period the substitution of 3 pounds of cottonseed meal for 4 pounds of the standard ration, thereby increasing the digestible protein in the ration .86 of a pound, had no effect whatever in varying the proportions of the milk. It is well to remember in this connection that nearly a month intervened between the first and second periods [1], and that the period itself covered five weeks. It is possible that, if the standard ration had contained a pound less of digestible protein daily, some difference may have been observed in the composition of the milk produced by the two herds in the second period.

Influence of Protein on the Milk Yield (Pounds).

Herd Results, Second Period.

Character of Ration.	Average Weight of Cow.	Total Yield of Milk.	Protein digested.	Protein required for Maintenance.	Protein in Milk.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
Standard, . . .	946	3,856.3	409.5	115.5	132.6	161.4	65.0
Cottonseed meal, .	939	3,898.1	560.0	115.5	136.8	307.7	122.0

In so far as this experiment throws any light on the protein requirements, it indicates that Herd I. was receiving ample protein (65 per cent. above the minimum requirement), and that the addition of more protein (122 per cent. above the minimum) was without any noticeable influence upon the milk yield.

Experiment IV.

This experiment was completed during the winter of 1897–98, although the results have not been published. It was conducted on the reversal method, with twelve mature grade Jersey cows, all of which had freshened the previous summer and autumn.

Weighing Animals. — Each animal was weighed for three

[1] This excessive lapse of time was due to some of the cows not being in best of condition.

consecutive days, before feeding in the afternoon, at the beginning and end of each half of the experiment.

Weighing and Sampling the Milk. — The weight of each milking was taken on a spring balance sensitive to 1 ounce, and the weights preserved on prepared record sheets. The milk was sampled for five consecutive days by the usual method, as described in accounts of the many feeding experiments given in previous reports. It was preserved with bichromate of potash and analyzed by gravimetric methods.

Character of Feeds. — The feeds used were all of good quality and of average composition. The hay was composed largely of Kentucky blue grass, sweet vernal grass and a liberal admixture of clover.

Dates of the Experiment.

First Half.

Dates.	Weeks.	High-protein Cows.	Low-protein Cows.
Nov. 13, 1897 to Jan. 14, 1898,	9	Guernsey, Midget, Susie, Beauty, Sadie, Alice.	Bessie, Mary, Mildred, Nina, Blossom, Jennie.
Second Half.			
Jan. 24 to March 27, 1898, .	9	Bessie, Mary, Mildred, Nina, Blossom, Jennie.	Guernsey, Midget, Susie, Beauty, Sadie, Alice.

It will be observed that ten days were allowed for changing the feeds given the animals.

Average Daily Rations fed to Each Cow (Pounds).

Character of Ration.	Wheat Bran.	Gluten Feed.	Corn Meal.	English Hay.	Corn Silage.
High protein, ...	3	5.5	–	10.9	25.7
Low protein, ...	3	1.5	4	11.0	25.7

It will be seen that the two rations were practically identical, excepting that 4 pounds of corn meal were substituted for a like amount of gluten feed. Different cows received from 10 to 12 pounds of hay and from 20 to 30 pounds of silage. Each animal received exactly the same amount of grain daily.

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

Character of Ration.	Dry Matter.	Digestible Organic Nutrients.				Nutritive Ratio.
		Protein.	Carbohydrates.	Fat.	Total Nutrients.	
High protein,	24.17	2.10	13.00	.50	15.60	1:6.7
Low protein,	24.24	1.67	13.70	.53	15.90	1:8.9

The herd averaged about 900 pounds in weight. The amount of dry matter and of total digestible nutrients fed in each ration was substantially the same; the high-protein ration contained about .4 of a pound more digestible protein than the low-protein ration. The excess over the low-protein ration is not marked and is very much less than that fed in experiments I. and II., previously mentioned.

Herd Gain in Live Weight (Pounds).

Character of Ration.	Gain or Loss.
High protein,	+353
Low protein,	+223

Both rations caused a gain in weight, the excess being in favor of the high-protein ration. This may have been expected, as the low-protein ration had rather too wide a ratio to be productive of the best results.

Protein Balance (Pounds).

Herd Results; Periods of Sixty-three Days.

Character of Ration.	Protein digested.	Protein required for Maintenance.	Protein contained in Milk (N. x 6.25).	Protein Excess over Maintenance and Milk Requirements.
High protein,	1,587.6	476.28	591.76	519.6
Low protein,	1,262.5	476.28	563.23	223.0

Influence of Protein on Milk Yield.

Herd Results in Pounds.

Character of Ration.	Average Weight of Cow.	Yield of Milk.	Daily Yield of Milk Per Cow.	Protein digested.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
High protein, . .	900	16,257	21.5	1,587.6	519.6	48.6
Low protein, . .	900	15,347	20.3	1,262.5	223.0	21.4

The average amount of digestible protein fed daily per cow in the high-protein ration — 2.10 pounds — could not be considered excessive, although it was 48.6 per cent. more than was required for milk and maintenance. The average amount of digestible protein fed daily per cow in the low-protein ration was 1.67 pounds, which was 21.4 per cent. above that necessary for milk and maintenance. The high-protein ration, being 48.6 per cent. in excess of the protein minimum, produced 5.9 per cent. more milk than did a ration made up of similar feedstuffs which was 21.4 per cent. in excess of the minimum. Such a difference in an experiment extending over a period of sixty-three days is believed to be too pronounced to be attributed to an experimental error, and is evidently the result of the increased amount of protein fed. In this connection it may be remarked that if the practical feeder purchased all of his grain, it would be to his advantage to buy gluten feed rather than corn meal. If he produces his own corn, the feeding of one-third bran, one-half corn and cob meal and one-sixth gluten feed would be advisable.

Composition of the Herd Milk (Per Cent.).

Character of Ration.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Protein Equivalent (N. x 6.25).	Ash.
High protein, . .	14.55	5.11	9.44	.58	3.64	.75
Low protein, . .	14.44	5.01	9.43	.59	3.67	.74

Samples of milk from each cow were taken weekly for five consecutive days, and tested for total solids and for fat. The average percentage produced by each cow for the nine weeks was multiplied by the amount of milk produced during the same period, and the amounts of total solids and of fat produced by the entire herd on each of the two rations calculated. These amounts, divided by the total milk yield, gave the average percentages of total solids and fat produced by each herd for the entire period.

The product of each milking of the six cows receiving the two different rations was also mixed, and composite five-day samples tested for total solids, fat, nitrogen and ash. In case of total solids and fat the average results varied less than .1 per cent. from those secured by the other method. The average results stated in the table above represent those secured by the last-described method.

It will be seen that the two rations produced milk of substantially the same composition. While the excess of protein appeared to have noticeably influenced the amount of the milk produced, it was without influence on its composition.

Experiment V. — 1898.

This experiment was conducted on the same plan as experiment IV., and the conditions were substantially the same. Nine cows only were used, being divided into herds of five and four.

Dates of the Experiment.

First Half.

Dates.	Days.	High-protein Cows.	Low-protein Cows.
April 4 to April 29, 1898, .	26	Blossom, Jennie, Bessie, Mary, Mildred.	Beauty, Alice, Guernsey, Midget.

Second Half.

Dates.	Days.	High-protein Cows.	Low-protein Cows.
May 8 to June 2, 1898, . .	26	Beauty, Alice, Guernsey, Midget.	Blossom, Jennie, Bessie, Mary, Mildred.

Nine days elapsed between halves, and the halves themselves lasted twenty-six days each. The "cow balance" was hardly

satisfactory in this experiment, five cows receiving one ration at the same time four were receiving the other, and *vice versa*. These were the only animals at the time that were in suitable condition.

Average Daily Rations fed to the Nine Cows (Pounds).

Character of Ration.	Wheat Bran.	Gluten Feed.	Corn Meal.	English Hay.	Rowen.
High protein,	3	5	–	9.3	9.3
Low protein,	3	1	4	9.3	9.4

These two rations differ only in that 4 pounds of corn meal took the place of a like amount of gluten feed.

Average Dry and Digestible Nutrients in Daily Rations (Pounds).

Character of Ration.	Dry Matter.	Digestible Organic Nutrients.				Nutritive Ratio.
		Protein.	Carbohydrates.	Fat.	Total Nutrients.	
High protein,	23.62	2.41	11.97	.43	14.81	1:5.4
Low protein,	23.44	1.96	12.39	.44	14.79	1:6.8

In the so-called low-protein ration the herd received substantially 2 pounds of digestible protein daily; in the high-protein ration this was increased .4 of a pound. The total digestible nutrients fed were the same in each case. The cows averaged 970 to 960 pounds in live weight during the two halves of the experiment. In the low-protein ration the amount of protein fed was sufficient to give satisfactory results.

Herd Gain in Live Weight (Pounds).

Character of Ration.	Gain or Loss.
High protein,	+76
Low protein,	+115

Protein Balance (Pounds).

Herd Results; Periods of Twenty-six Days.

Character of Ration.	Protein digested.	Protein required for Maintenance.	Protein contained in Milk.	Protein Excess over Maintenance and Milk Requirements.
High protein,	563.9	156.8	184.4	222.7
Low protein,	458.6	155.5	174.8	128.3

Influence of Protein on Milk Yield.

Herd Results in Pounds.

Character of Ration.	Average Weight of Cow.	Yield of Milk.	Daily Yield of Milk Per Cow.	Protein digested.	Protein Excess over that required for Maintenance and Milk.	Percentage Excess.
High protein,	960	4,693.5	20.06	563.9	222.7	65.3
Low protein,	950	4,370.6	18.68	458.6	128.3	39.0

The average amount of digestible protein fed daily to each cow in the high-protein ration was 2.41 pounds, and the excess over that required for milk and maintenance was 65.3 per cent. In the low-protein ration each cow received 1.96 pounds daily, and an average excess of 39 per cent. above requirements.

During the high-protein feeding the herd produced 7.4 per cent. more milk than when it received the low-protein ration, showing the influence of the larger amount. Whether all of the milk increase was due to the extra protein consumed is uncertain. The low-protein ration naturally had a wider ratio, and evidently was rather better suited to fattening than to milk production, and was indicated by the increase in live weight.

Composition of the Herd Milk (Per Cent.).

Character of Ration.	Total Solids.	Fat.	Solids not Fat.	Nitrogen.	Protein Equivalent (N x 6.25).	Ash.
High protein,	14.83	5.00	9.84	.63	3.93	.74
Low protein,	14.90	5.07	9.82	.66	4.00	.76

The above figures represent the average of five-day composite samples of the milk produced by the herd of nine cows while on the two different rations. Samples of *each cow's* milk were also tested five days in each week for total solids and fat. The average of the two herds by this method varied less than .1 per cent. from the above figures. It is, therefore, evident that the difference in the amount of protein in the ration did not vary the fat, solids not fat, nitrogen or ash content of the milk.

Experiment VI. — 1905–06.

This experiment, hitherto not reported, was carried out by the group method, six cows constituting each of two groups.

The object of the experiment was to note the effect of a ration low in digestible protein, — the amount required in the milk plus that for maintenance, — as compared with one containing approximately ½ pound in excess. The effect of the two rations was to be noted (*a*) on the condition of the animals; (*b*) on the yield of milk, milk solids, fat and nitrogen; (*c*) on the relative shrinkage; (*d*) on the composition of the milk.

Plan of the Experiment. — The twelve cows were divided as evenly as possible into two groups. The first few weeks both groups received the low-protein ration in order to establish a basis for comparison. The record of the milk yield and its composition is reported for the last week of this preliminary period. At the beginning of the period proper, Group II. received the high-protein ration, and Group I. continued on that low in protein.

History of the Cows.

Name.	Breed.	Age (Years).	Last Calf dropped.	Days with Calf, Beginning of Test.
Blanche,	Grade Guernsey,	10	October, 1905	57
Daisy,	Grade Jersey,	7	August, 1905	79
Fancy,	Grade Jersey,	6	August, 1905	79
Gladys,	Pure Jersey,	3	December, 1905	–
Maude,	Grade Guernsey,	2	December, 1905	18
May,	Grade Jersey,	10	July, 1905	68
Betty,	Grade Jersey,	2	November, 1905	–
Dora,	Grade Jersey,	12	August, 1905	–
May Rio,	Pure Jersey,	3	October, 1905	64
Molly,	Grade Jersey,	10	July, 1905	–
Red II.,	Grade Jersey,	10	November, 1905	20
Samantha,	Grade Jersey,	3	August, 1905	51

Weighing Cows. — Each cow was weighed for three consecutive days at the beginning and end of the period proper, before watering and feeding in the afternoon. These weights were also taken twice during the intervening time.

Sampling Feeds. — Samples of hay and silage were taken at the beginning of the period, and every two weeks thereafter. In case of the hay, forkfuls were taken here and there from the entire amount to be fed for the day, run through a feed cutter, subsampled, the final sample brought to the laboratory in glass-stoppered bottles, dry-matter determinations made at once and the sample saved for a composite. The silage was similarly sampled, excepting that it was not run through the cutter. The grain was sampled daily, preserved in glass-stoppered bottles, and at the end of the period analyzed.

Sampling Milk. — The milk of each cow was sampled for five consecutive days in each week by the usual method, and the composite tested for fat, total solids, nitrogen and ash.

Dates of the Experiment.

Preliminary Period.

Herd.	Character of Ration.	Dates.	Weeks.	Cows.
I., . . .	Low protein, .	January 27 through February 2.	1	Blanche, Daisy, Fancy, Gladys, Maude, May.
II., . . .	High protein, .	January 27 through February 2.	1	Betty, Dora, May Rio, Molly, Red II., Samantha.

Period Proper.

Herd.	Character of Ration.	Dates.	Weeks.	Cows.
I., . . .	Low protein, .	February 10 through April 27.	11	Blanche, Daisy, Fancy, Gladys, Maude, May.
II., . . .	High protein, .	February 10 through April 27.	11	Betty, Dora, May Rio, Molly, Red II., Samantha.

Average Daily Rations consumed by the Two Herds (Pounds).

Preliminary Period.

Herd.	Character of Ration.	English Hay.	Corn Silage.	Wheat Bran.	Corn Meal.	Gluten Meal.
I., ...	Low protein, .	12.6	22.5	3.4	3.3	–
II., ...	Low protein, .	12.6	22.2	3.4	3.3	–

Period Proper.

Herd.	Character of Ration.	English Hay.	Corn Silage.	Wheat Bran.	Corn Meal.	Gluten Meal.
I., ...	Low protein, .	12.6	22.2	3.4	3.3	–
II., ...	High protein, .	13.0	21.0	3.7	1.2	2.2

The amount of hay fed to the different cows varied from 11 to 15 pounds; silage, from 20 to 30 pounds; bran, from 3 to 4.5 pounds; corn meal, from 3 to 4.5 pounds, and gluten meal, from 2 to 3 pounds daily.

Average Amounts of Dry and Digestible Matter consumed by Each Cow daily (Pounds).

Preliminary Period.

Herd.	Character of Ration.	Dry Matter.	Protein.	Fiber.	Extract Matter.	Fat.	Total.	Nutritive Ratio.
I., . . .	Low protein, .	21.75	1.22	3.58	8.39	.42	13.61	1:10.6
II., . . .	Low protein, .	22.51	1.27	3.63	8.68	.43	14.02	1:10.4
Period Proper.								
I., . . .	Low protein, .	21.70	1.22	3.58	8.37	.41	13.58	1:10.5
II., . . .	High protein, .	22.18	1.76	3.60	8.14	.41	13.91	1: 7.2

Herd I. averaged 912 pounds and Herd II. 903 pounds in live weight. On the basis of 1,000 pounds live weight, Herd I. would be receiving 1.34 pounds of digestible protein and 14.9 pounds total digestible matter, and Herd II., 1.95 pounds digestible protein and 15.4 pounds of total digestible matter daily in the period proper. The digestible matter was calculated from actual analyses of the feeds, and average digestion coefficients. It seems probable that the results are a trifle low, and that more material was actually digested than the calculations show, for the animals appeared well nourished, Herd I. gaining 225 pounds, and Herd II., 215 pounds during the eleven weeks of the period proper. The low-protein ration was evidently somewhat deficient in protein and too wide. The high-protein ration must have satisfied the protein requirements, and on the basis of 1,000 pound's live weight, it contained .6 of a pound more of digestible protein daily than did the other ration.

Weight of Animals at Beginning and End of Experiment (Pounds).

Herd.	Period.	Blanche.	Daisy.	Fancy.	Gladys.	Maude.	May.	Betty.	Dora.	May Rio.	Molly.	Red II.	Samantha.	Gain or Loss.
I.,	Beginning,	1,167	837	835	732	778	1,010	–	–	–	–	–	–	–
	End,	1,230	892	865	707	813	1,077	–	–	–	–	–	–	+225
II.,	Beginning,	–	–	–	–	–	–	672	843	758	1,018	1,007	1,013	–
	End,	–	–	–	–	–	–	712	877	808	1,088	1,063	978	+215

Judging from the above weights it would appear that both herds were well nourished and able to add slightly to their live weight.

Crude Protein Balance (Pounds).

Preliminary Period: One Week.

Character of Ration.	Protein digested.	Protein for Maintenance.	Protein for Milk.	Protein Deficit.	Percentage Deficit.
Low protein, Herd I.,	51.3	30.4	27.18	—6.28	—11.0
High protein, Herd II.,	53.3	30.4	28.66	—5.76	—9.7

Crude Protein Balance (Pounds).

Period Proper, Eleven Weeks.

Herd.	Character of Ration.	Cows.	Protein digested.	Protein required for Maintenance.	Protein required in Milk (N. x 6.25).	Excess over Maintenance and Milk Requirements.	Percentage Excess.
II.,	High protein,	Betty,	118.58	37.30	45.87	35.41	42.6
		Dora,	124.74	46.35	53.55	24.84	24.9
		May Rio,	128.59	42.20	49.82	36.57	39.7
		Molly,	133.21	56.76	52.48	23.97	21.1
		Red II.,	174.02	55.79	70.01	48.22	38.3
		Samantha,	133.21	53.68	56.54	22.99	20.9
I.,	Low protein,	Blanche,	104.72	64.68	43.55	—4.51	—4.2
		Daisy,	99.79	46.62	44.20	6.97	7.7
		Fancy,	92.40	45.82	49.49	—2.91	—3.1
		Gladys,	93.90	38.81	50.88	4.21	4.7
		Maude,	77.77	42.85	34.98	—.06	±
		May,	96.25	56.27	49.49	—9.51	—9.0

Influence of Protein on Milk Production (Pounds).

Preliminary period: both herds, low-protein ration.

Ration.	Average Weight of Cow.	Digestible Protein consumed daily per Cow.	Percentage Deficit or Excess Protein over Requirements.	Total Milk Yield.	Daily Average Yield.	Yield of Solids.	Yield of Fat.	Yield of Protein (N. x 6.25).
Low,	–	1.22	—11.0	747.8	17.80	108.95	37.97	27.18
Low,	–	1.27	—9.7	821.3	19.55	115.66	40.67	28.66
Percentage excess, Herd IV. over Herd I.	–	–	–	9.8	–	6.20	7.00	5.50

Period proper: Herd I., low protein; Herd II., high protein.

Ration.	Average Weight of Cow.	Digestible Protein consumed daily per Cow.	Percentage Deficit or Excess Protein over Requirements.	Total Milk Yield.	Daily Average Yield.	Yield of Solids.	Yield of Fat.	Yield of Protein (N. x 6.25).
Low,	912	1.22	±	7,415.6	16.05	1,102.10	398.90	272.60
High,	903	1.76	31.3	8,906.5	19.28	1,294.80	473.00	328.30
Percentage increase, high over low.	–	–	–	20.1	–	17.50	18.60	20.00

It was hardly possible, with the cows at our disposal, to select two herds of six each that would produce substantially equal amounts of milk. It will be seen, therefore, that Herd II. in the preliminary period was producing nearly 10 per cent. more milk and from 5.5 to 7 per cent. more protein and fat than Herd I.

In the second or period proper, covering eleven weeks, this percentage was increased from 9.8 to 20 in case of the milk; substantially similar increases were also noted in case of the milk ingredients. Otherwise expressed, Herd II., receiving the high-protein ration, nearly maintained its flow during the second period, while each cow in Herd I. showed an average daily decrease of 1.75 pounds, or practically 10 per cent.

In the preliminary period both herds were receiving from 10 to 11 per cent. less protein than was actually needed for maintenance and milk. In the second period the low-protein herd had approximately reached a balance between income and outgo, while the high-protein herd was receiving 31.3 per cent. of crude protein in excess of requirements. The effect

of this extra protein may be clearly seen in maintaining the flow of milk. It would be of interest to know whether it would have maintained its influence throughout the entire milking period. The herd receiving the shortage of protein was obliged to adjust itself to the low-protein diet. It was able to increase somewhat in live weight (fat?), but its milk flow was of necessity noticeably checked. It is quite probable that some cows of pronounced ability as milkers would not shrink as rapidly as others on a low-protein diet, but for a time would have taken the needed protein from that stored in the body.

Effect of Protein on Average Composition of the Milk (Per Cent.).

Herds.	Period.	Character of Ration.	Total Solids.	Fat.	Solids not Fat.	Protein.
I.,	I.,	Low protein,	14.57	5.08	9.49	3.63
I.,	II.,	Low protein,	14.86	5.38	9.48	3.69
Increase,	-	-	.29	.30	±	.06
II.,	I.,	Low protein,	14.08	4.95	9.13	3.49
II.,	II.,	High protein,	14.54	5.31	9.23	3.69
Increase,	-	-	.46	.36	.10	.20

The above average figures were secured by taking the average of the weekly analysis of the milk produced by each cow and multiplying it by the pounds of milk produced, the result being the pounds of the several ingredients produced by each cow. These were added, and gave the total milk and milk ingredients produced by each herd. The total ingredients divided by the total milk produced gave the average percentages. The fact that the milk produced by each herd did not show the same composition in the preliminary period prevents a direct comparison. It will be observed, however, that in case of Herd I. the milk in the second period changed but little in composition from that produced in the first period, the principal difference being a slight increase in the fat, due evidently to the advance in lactation. Herd II. produced milk also with only slight variations in the two periods. The fat increased .36 of 1

per cent., being about the same increase as with Herd I. The protein showed rather more of an increase than in case of Herd I., and this may possibly be attributed to the influence of the extra protein in the food. It must be remembered that Herd I. received a ration deficient in protein, and the increased amount given to Herd II. may have had a slight effect upon the milk protein. With this exception it is safe to state that the protein was entirely without influence upon the composition of the milk.

Experiment VII. — 1907–08.

This experiment was conducted with six cows, the only ones available at the time, and was by the group method.

The object of the experiment was primarily to note the effect of rations low and high in protein (a) upon the condition of the animals, (b) upon the yield of milk, and (c) upon the relative milk shrinkage.

The plan of the experiment consisted in dividing six cows into two herds of three each, which were known as Herds D and E. The first ten days were regarded as preliminary, to accustom the two herds to their distinct rations. Herd D received the low-protein ration and Herd E the one high in protein.

Weighing Cows. — Each of the cows was weighed for three consecutive days at the beginning and end of the experiment, and every fourth week during its progress. They were weighed in the afternoon before being fed or watered.

Sampling Feeds. — The hay was sampled in the usual way at the beginning of the experiment, and every two weeks thereafter. The grain was sampled daily and preserved in glass-stoppered bottles, and eventually tested for dry matter and for the ordinary ingredients.

Character of Feeds. — The hay was a mixture of grasses, the finer varieties, such as Kentucky blue grass, predominating. It contained a noticeable admixture of clover.

Sampling Milk. — The cows were milked twice daily, and the single milking of each cow in each herd was poured into a common receptacle, mixed and the herd mixture sampled. This method was continued for five consecutive days, each single

sample composited, and eventually tested for solids, fat and nitrogen. It will therefore be seen that herd samples only were analyzed, and not the product of individual cows.

History of Cows.

Herd.	Cows.	Breed.	Age (Years).	Last Calf dropped.	Days with Calf at Beginning of Trial.
D,	Samantha,	Jersey-Holstein,	4	September 3	8
	May Rio,	Pure Jersey,	4	September 12	–
	Daisy,	Grade Jersey,	8	August 23	–
E,	Fancy,	Grade Jersey,	7	September 1	–
	Gladys,	Pure Jersey,	4	October 7	–
	Red III.,	Grade Jersey,	2	October 27	–

Duration of the Experiment.

Herd.	Character of Ration.	Dates.	Number of Weeks.	Cows.
D,	Low protein,	Nov. 23, 1907, through May 8, 1908.	24	Samantha, May Rio, Daisy.
E,	High protein,	Nov. 23, 1907, through May 8, 1908.	24	Fancy, Gladys, Red III.

Rations consumed daily by Each Cow (Pounds).

Herd.	Character of Ration.	Cows.	Hay.	Wheat Bran.	Corn Meal.	Gluten Feed.
D,	Low protein,	Samantha,	22	3.40	4.50	–
		May Rio,	20	3.00	4.00	–
		Daisy,	20	3.00	4.00	–
E,	High protein,	Gladys,	20	3.00	–	3.90
		Fancy,	22	3.40	–	4.60
		Red III.,	16	2.50	–	3.40
Average, Herd D,	–	–	20.7	3.13	4.16	–
Average, Herd E,	–	–	19.3	2.97	–	3.97

The difference in the two rations consisted in the substitution of corn meal for gluten feed. The latter, as is well known,

is a by-product of the former, hence the general character of the two variables was the same, and particularly the protein.

Digestible Matter in Daily Rations (Pounds).

Herd.	Character of Ration.	Cows.	Digestible Nutrients. Protein.	Fat.	Carbohydrates.	Total.	Nutritive Ratio.
D, . .	Low protein, .	Samantha, .	1.44	.48	14.27	16.19	1:10.7
		May Rio, .	1.29	.43	12.87	14.59	1:10.6
		Daisy, . .	1.29	.43	12.87	14.59	1:10.6
E, . .	High protein, .	Gladys, . .	1.88	.38	12.23	14.49	1:6.9
		Fancy, . .	2.14	.43	13.65	16.22	1:6.8
		Red III., .	1.58	.31	9.97	11.86	1: 6.6
Average, Herd D,	–	–	1.34	.45	13.34	15.12	1:10.6
Average, Herd E,	–	–	1.87	.37	11.95	14.19	1:6.7

The above figures were secured from the actual analyses of the feeds and average digestive coefficients. It is clear that Herd D received a ration with a very wide nutritive ratio, while Herd E received a ration with a medium ratio.

Average Weight of Cows at Beginning and End of Period (Pounds).

	Herd D. Daisy.	May Rio.	Samantha.	Herd E. Fancy.	Gladys.	Red III.
Beginning, . .	920	898	1,003	973	810	680
End, . . .	923	907	1,063	1,013	818	782
Total gain, Herd D, 69 pounds.				Total gain, Herd E, 150 pounds.		

Herd E made a larger gain than Herd D, but this appears to be due largely to the gain made by Red III., a heifer with first calf.

Crude Protein Balance (Pounds).

Herd.	Character of Ration.	Average Weight.	Protein digested (N. x 6.25).	(Protein required for Maintenance (N. x 6.25.)	Protein required for Milk (N. x 6.25).	Protein Excess or Deficit.	Percentage Excess or Deficit.
D, . .	Low protein,	935	675.36	328.00	351.50	—4.14	—.6
E, . .	High protein,	832	942.48	291.75	389.37	261.36	38.4

The total protein digested was calculated from the amount digested daily multiplied by the number of days of the experiment. The protein for maintenance was calculated from the average weight of each herd, allowing .7 of a pound of digestible protein per 1,000 pounds live weight. The protein in the milk was calculated from the actual analysis of the milk. It is admitted that the above results are only approximate, being secured partly from average figures, and on the basis of crude in place of true protein. They indicate, however, that Herd D was receiving a ration rather deficient in protein, and that Herd E was receiving at least 38.4 per cent. over that required for maintenance and milk.

Milk Yield and Milk Shrinkage.

Herd.	Character of Ration.	Milk produced and Shrinkage.			
		Total Yield (Pounds).	First Week (Pounds).	Last Week (Pounds).	Per Cent. Shrinkage.
D, ...	Low protein, .	9,287.1	446.3	368.8	17.4
E, ...	High protein, .	11,161.5	514.5	401.6	21.9

In spite of the fact that the three cows comprising Herd D received hardly sufficient protein for maintenance and milk produced, they did not shrink as much during a period of twenty-four weeks as did the three cows in Herd E, which received substantially 38 per cent. protein in excess of supposed requirements. Such a result can only be explained on the ground that the animals were too few in number to give accurate results by the group method, and that individuality rather than food appeared to be the controlling factor. See also Experiment VIII.

Experiment VIII. — 1908–09.

This experiment was planned primarily to study the protein requirements of dairy animals. It will not show the effect of protein upon the chemical composition of the milk.

Plan of the Experiment. — Inasmuch as the cows in the herd calved at different times, the experiment was planned with pairs of cows, *i.e.,* each pair of cows, when ready, was started,

one on a diet approximately sufficient to furnish protein for maintenance plus that contained in the milk, and the other on a diet containing some ½ pound more protein daily than the maintenance and milk requirements.

Duration of the Experiment. — The experiment was planned to continue substantially through a milking period, or until the animals were so far advanced in lactation as to cease to respond to the influence of food.

Weighing the Cows. — Each animal was weighed for three consecutive days at the beginning of the period, and for three days each two weeks thereafter.

Sampling Feeds. — The hay fed was sampled at the beginning of the period for each pair of cows, and each two weeks thereafter. The samples were placed in glass-stoppered bottles, taken to the laboratory and dry-matter determinations made at once. The method of sampling has been described in preceding experiments.

Each kind of grain was sampled daily during the process of weighing out, and the composite samples preserved in glass-stoppered bottles. Dry-matter determinations were made once each month, and the monthly samples composited.

Character of Feeds. — It was intended to procure one lot of hay of the same quality sufficient to last during the entire experiment. Owing to several unfortunate circumstances this was not possible. Three different lots were secured, and composite samples of each analyzed. The digestibility was not determined, but approximate coefficients applied, depending upon the analysis and general appearance of the hay. The several grains were procured in large amounts and average digestion coefficient applied.

Sampling Milk. — The milk of each cow was sampled for five consecutive days at the beginning of the period, and each two weeks thereafter. It was tested for total solids, for fat by the Babcock method in duplicate, and for nitrogen by the Kjeldahl method.

History of the Cows.

PAIRS.	Cows.	Breed.	Age (Years).	Last Calf dropped.	Daily Yield at Beginning of Experiment. Pounds.
I.,	Minnie,	Grade Holstein,	8	September 12,	26.0
	Mary,	Grade Holstein,	10	September 5,	26.0
II.,	Samantha,	Jersey-Holstein,	6	August 27,	26.0
	Chub,	Grade Holstein,	10	September 1,	20.0
III.,	Betty,	High-grade Jersey,	4	September 25,	26.3
	May Rio,	Pure Jersey,	6	October 13,	27.5
IV.,	Daisy,	High-grade Jersey,	11	October 22,	28.7
	Cecile,	Pure Jersey,	4	October 10,	25.7
V.,	Red III.,	High-grade Jersey,	2	October 30,	29.0
	Betty II.,	High-grade Jersey,	2	–	–

Duration of Experiment.

Cows.	Preliminary Period began.	Period Proper.	Number of Days.
Minnie,	October 10,	October 17 through April 30,	196
Mary,	October 10,	October 17 through April 30,	196
Samantha,	October 10,	October 17 through May 28,	224
Chub,	October 10,	October 17 through May 28,	224
Betty,	October 24,	November 14 through June 11,	210
May Rio,	October 24,	November 14 through June 11,	210
Daisy,	October 31,	November 14 through May 28,	196
Cecile,	October 31,	November 14 through May 28,	196
Red III.,	November 28,	December 12 through June 11,	182
Betty II.,	December 17,	December 26 through June 11,	168

Rations consumed daily by Each Cow (Pounds).

Character of Ration.	Number of Days.	Cows.	Hay.	Wheat Bran.	Corn Meal.	Gluten Feed.
High protein,	196	Mary,	21.4	3.0	–	3.93
	224	Chub,	17.6	3.0	–	3.51
	210	Betty,	19.4	3.0	.80	3.87
	196	Cecile,	17.0	3.0	.43	3.48
	168	Betty II.,	16.4	3.0	1.00	3.00
Low protein,	196	Minnie,	20.0	3.0	3.51	.51
	224	Samantha,	22.0	3.9	3.90	–
	210	May Rio,	19.6	3.0	4.80	–
	196	Daisy,	19.3	3.0	4.00	.44
	182	Red III.,	19.5	3.0	4.00	.41
Average, high protein,	–	–	18.4	3.0	.74	3.56
Average, low protein,	–	–	20.1	3.2	4.10	.45

The substantial difference in the rations of the two lots of cows consisted in the fact that the high-protein cows received the gluten feed and the low-protein cows the corn meal.

Dry and Digestible Matter in Daily Rations (Pounds).

Character of Ration.	Cows.	Dry Matter.	Digestible. Protein.	Digestible. Fat.	Digestible. Carbohydrates.	Digestible. Total.	Nutritive Ratio.
High protein,	Mary,	25.1	2.05	.55	12.26	14.86	1:6.57
	Chub,	21.3	1.79	.38	10.41	12.58	1:6.28
	Betty,	23.9	1.95	.43	12.04	14.42	1:6.66
	Cecile,	21.1	1.74	.38	11.06	13.18	1:6.84
	Betty II.,	20.7	1.61	.38	10.32	12.31	1:6.93
Low protein,	Minnie,	23.8	1.47	.42	12.23	14.12	1:8.95
	Samantha,	26.0	1.44	.43	12.90	14.77	1:9.62
	May Rio,	24.2	1.36	.44	12.70	14.50	1:10.51
	Daisy,	22.7	1.34	.39	11.61	13.34	1:9.30
	Red III.,	23.7	1.36	.41	12.63	14.40	1:9.95
Average, high protein,	–	22.4	1.83	.42	11.22	13.47	1:6.65
Average, low protein,	–	24.1	1.39	.42	12.41	14.27	1:9.61

It will be seen that the cows receiving the larger amount of protein did not receive by .8 of a pound as much total digesti-

ble matter as the low-protein cows. The amount of food fed daily to each cow was gauged partly by the appetite of the animal. The high-protein cows received only .44 of a pound more digestible protein than the other herd.

Influence of Rations on Weight (Pounds).

Character of Ration.	Cows.	Average Weight.	Weight at Beginning.	Weight at End.	Total Gain or Loss.
High protein,	Mary,	1,074	1,047	1,102	+55
	Chub,	1,011	955	1,067	+112
	Betty,	869	843	895	+52
	Cecile,	805	783	827	+44
	Betty II.,	743	742	745	+03
Low protein,	Minnie,	971	923	1,018	+95
	Samantha,	1,068	995	1,142	+147
	May Rio,	826	825	827	+02
	Daisy,	830	798	862	+64
	Red III.,	837	807	867	+60
Herd average, high,	–	900	874	927	+266
Herd average, low,	–	906	869	943	+368

The cows receiving the low-protein ration gained rather more in weight than the other herd; whether this was due to the character of the ration, or whether it simply depended upon the individuality of the animal, it is difficult to say.

True[1] Protein Balance (Pounds).

Character of Ration.	Cows.	True Protein digested.	Protein required for Maintenance.	Protein found in Milk. (N. x 6.25).	Excess over Maintenance and Milk Requirements.	Percentage Excess.
High protein,	Mary,	350.97	147.35	143.10	60.52	20.8
	Chub,	368.24	158.52	124.71	85.01	30.0
	Betty,	380.61	127.74	156.35	96.52	34.0
	Cecile,	316.38	110.45	136.07	69.86	28.3
	Betty II.,	256.82	87.37	114.69	54.75	27.1
Low protein,	Minnie,	277.15	133.22	143.73	00.20	+
	Samantha,	320.40	167.46	168.14	—15.20	—4.5
	May Rio,	284.48	121.42	136.07	26.99	10.5
	Daisy,	259.20	113.87	140.52	4.80	1.9
	Red III.,	247.13	106.63	119.58	20.92	9.2

The high-protein cows received an average of 28 per cent. of protein over maintenance and milk requirements, while in case of the low-protein cows the percentage varied from an actual shortage of 4.5 per cent. to a surplus of 10.5 per cent.

[1] Amines were determined and deducted from the total protein, the above results being expressed as true albuminoids.

Milk Yield and Milk Shrinkage (Pounds).

Character of Ration.	Cows.	Milk produced and Shrinkage. Total.	First Two Weeks.	Last Two Weeks.	Per Cent. Shrinkage.	Weekly Shrinkage (Per Cent.).	Total Solids produced and Per Cent. Shrinkage. Total.	First Two Weeks.	Last Two Weeks.	Per Cent. Shrinkage.	Weekly Shrinkage (Per Cent.).
High protein,	Mary,	4,224.7	341.4	173.6	49.2	2.0	567.3	44.3	25.7	42.0	1.7
	Chub,	3,684.1	263.6	173.4	34.6	1.2	483.5	33.1	22.7	31.4	1.1
	Betty,	4,086.0	343.4	208.4	39.3	1.5	599.6	49.9	29.7	40.5	1.6
	Cecile,	3,677.1	306.4	206.4	32.6	1.3	533.5	43.6	29.7	31.8	1.3
	Betty II.,	3,235.3	286.0	234.8	17.6	.89	430.2	39.6	30.1	24.0	1.2
Low protein,	Minnie,	4,183.3	329.1	251.6	23.6	1.0	457.5	42.2	33.5	20.7	.9
	Samantha,	4,370.0	305.5	231.9	24.1	.86	673.0	46.0	34.4	25.1	.9
	May Rio,	4,323.0	368.7	228.6	38.0	1.50	627.7	53.1	33.1	37.7	1.5
	Daisy,	3,643.5	352.9	202.4	42.6	1.8	545.9	50.1	30.0	40.2	1.7
	Red III.,	3,720.3	357.5	210.4	41.1	1.9	502.9	48.0	28.4	40.8	1.9
Average, high,		–	–	–	34.7	1.4	–	–	–	34.0	1.4
Average, low,		–	–	–	33.9	1.4	–	–	–	32.9	1.4

Influence of Protein on Milk Shrinkage (Average Results).

Character of Ration.	Weight of Cow (Pounds).	Digestible Protein consumed daily per Cow (Pounds).	Percentage Excess of Protein over Requirements.	Total Shrinkage (Per Cent.).	Weekly Shrinkage (Per Cent.).
High protein,	900	1.83	22	34.7	1.4
Low protein,	906	1.39	3	33.9	1.4

The average amount of digestible protein consumed daily by each of the high-protein cows (1.83 pounds) was not quite as high as intended, hence the difference between the low and high protein rations was not particularly pronounced. Nevertheless, one would expect if the conditions were reasonably satisfactory that the low-protein cows would have shrunk in their milk yield (over an average of two hundred days) rather more than the high-protein cows. Such, however, was not the case, the shrinkage of both herds being substantially identical. The only explanation that can be offered is the undue influence of individuality and the small number of cows in each group. For example, Mary shrunk 49 per cent. during the experiment, it being characteristic of this animal to dry off quite rapidly after she had been four months with calf; Daisy also had such a tendency. The individuality of each animal, as well as its age and condition, all have a pronounced influence, especially when the experiment is extended over a long period of time, and in order to arrive at the truth a large number of animals must be used with as near similar conditions as it is possible to secure. Is it probable that if an animal receives sufficient protein to supply the daily demands of her body (maintenance) and of the milk produced, she will not shrink in her yield *during a milking period* any more than when she is receiving 25 to 50 per cent. protein in excess of the actual requirements? In other words, is it not possible that the excess protein acts as a stimulus for a time, after which the individuality of the animal becomes the more pronounced factor?

Conclusions.

The following general conclusions may be drawn from the experiments reported: —

1. A large excess of digestible protein (1.5 pounds, or 100 per cent.) above the protein minimum increased the flow of milk some 15 per cent. in experiments extending over periods of four weeks.

2. No particular difference was noted in the milk yield in case of two herds of cows receiving the same amount of total digestible matter, one receiving 65 per cent. and the other 122 per cent. of digestible protein above the protein minimum. Such a result indicates, at least, that the former excess was sufficient.

3. A 50 per cent. excess of digestible protein daily above the protein minimum in an experiment by the reversal method, extending over a period of nine weeks, produced some 5.9 per cent. more milk than did a ration with 21 per cent. excess protein.

4. Under similar conditions an excess, above the minimum, of 65 per cent. digestible protein produced 7.4 per cent. more milk than did an excess of 39 per cent. (experiment covered twenty-six days).

5. In experiment VI., extending over a period of eleven weeks with twelve cows, by the group method, an excess of .54 of a pound of protein, or 31.3 per cent., over the protein minimum, produced an apparent increase of 10 per cent. in the milk yield.

In experiment VIII., extending over periods of twenty-four to thirty weeks with ten cows, by the group method, the cows receiving the protein minimum did not shrink any more than those receiving each .44 of a pound, or 28 per cent., protein above the minimum.

6. The group method of experimentation is best suited for conducting experiments where a relatively large number of animals — twenty or more — is available. With a less number the influence of individuality is altogether too pronounced.

7. An excess of 30 per cent. of digestible crude protein above the protein minimum (equal to 1.80 pounds of protein per

day) will be productive of satisfactory results in case of cows weighing 900 pounds and producing daily 12 quarts of 4 per cent. milk.[1]

An excess of 50 per cent. of digestible crude protein above the protein minimum is believed to be ample for all ordinary requirements.

8. Protein in excess of the above suggested amounts may temporarily increase the milk yield, but it seems probable that in many cases the influence of individuality is likely to be more pronounced than the effect of the protein consumed.

9. Under the usual conditions, varying amounts of protein appear to be without influence upon the composition of the milk.

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[1] Armsby, in Farmers' Bulletin No. 346, United States Department of Agriculture, expresses substantially the same idea in allowing .05 of a pound of digestible true protein for each pound of average milk, in addition to the maintenance requirement of .5 of a pound of digestible true protein per 1,000 pounds live weight. It is possible that animals can even do very good work with .04 of a pound of protein for each pound of milk.

THE DETERMINATION OF ARSENIC IN INSECTICIDES.

BY E. B. HOLLAND.

During the past three years the writer [1] has given considerable time to the study of arsenical insecticides, with special reference to their manufacture, composition and use, — the main object of which was to provide the entomological department of this station with chemicals of known composition, suitable for an extended investigation to determine their effect in practical application under varying climatic and atmospheric conditions.

For more than a decade the analysis of arsenicals has received marked attention because of the high value of a number of these salts as insecticides. The sale of inferior, adulterated or imitation products lacking in efficiency, or causing severe injury to foliage, has rendered necessary a certain amount of supervision by the agricultural experiment stations of the country. In several States special laws have been enacted to regulate the sale and to provide for an inspection of such materials. Arsenic as trioxide or pentoxide is the active constituent of these compounds, and various methods of several distinct types and numerous modifications have been proposed for its determination. Some of the methods are applicable to arsenous acid and others to arsenic acid.

Methods.

As the work planned by the entomological department would require many analyses, it was desirable that the methods adopted should be reasonably short and simple, though accuracy would be the controlling factor. The literature on the determination of arsenic was reviewed at some length. The results, while somewhat overwhelming, can be roughly summarized under gravimetric methods, volumetric methods and processes for the elimination of substances liable to affect the determination. A

[1] Assisted by Dr. R. D. MacLaurin, Prof. S. F. Howard, C. D. Kennedy and J. C. Reed.

classification of this character is open to criticism, but will serve the purpose intended.

The gravimetric methods include the hydrogen sulfide precipitation of arsenous acid [1] weighable as arsenous sulfide after removal of the excess sulfur; the Neher modification [2] of the Bunsen method,[3] precipitating arsenic acid with hydrogen sulfide, weighable as arsenic sulfide; the modified Levol method, precipitating arsenic acid with "magnesia mixture," weighable as magnesium pyro-arsenate; and the Werther method,[4] precipitating arsenic acid with uranyl acetate, weighable as uranyl pyro-arsenate. The inherent faults of the sulfide methods render them impracticable. The modified Levol method, the most prominent of the gravimetric, is complicated, tedious and tends towards low results. All of these methods are time consumers, and none of them appear to have met with favor, having of late been almost entirely superseded by volumetric.

The volumetric methods include the Kessler method,[5] oxidizing arsenous acid with potassium bichromate and titrating the excess chromic acid with standard ferrous sulfate, using potassium ferri-cyanide to determine the end point; the permanganate method, titrating arsenous acid with standard potassium permanganate to a rose color; the Mohr method, titrating arsenous acid with standard iodine in the presence of sodium bicarbonate, using starch paste as indicator; the Bunsen method,[6] based on the difference in amount of chlorine evolved from hydrochloric acid by a given weight of potassium bichromate in the presence of arsenous acid, the gas being conducted into potassium iodide and the free iodine titrated with standard sodium thiosulfate, using starch paste as indicator; the Krickhaus method,[7] reducing arsenic acid to arsenous with hydrochloric acid and potassium iodide, and titrating the free iodine with standard thiosulfate; the Bennett modification [8] of the Pierce method,[9] precipitating arsenic acid with silver nitrate and titrating the silver in the precipitate with potassium sulphocyanate, according to Volhard; [10] and the Bödeker method,[11] titrating arsenic acid with

[1] Fresenius, Quan. Chem. Anal.
[2] Ztschr. Analyt. Chem., 32, 45 (1893).
[3] Ann. Chem. Pharm., 192, 305.
[4] Jour. Prakt. Chem., 43, 346 (1848).
[5] Poggend. Ann., 118, 17, Series 4 (1863).
[6] Ann. Chem. Pharm., 86, 290.
[7] Engin. and Min. Jour., 90, 357. See Sutton for earlier references.
[8] Jour. Amer. Chem. Soc., 21, 431 (1899).
[9] Proc. Col. Sci. Soc., Vol. 1.
[10] Liebig's Ann. Chem., 190, 1 (1878).
[11] Ann. Chem. Pharm., 117, 195.

standard uranyl nitrate, using potassium ferrocyanide to determine the end point. The Kessler and Bödeker methods are objectionable in their requirement of an "outside" indicator. The Bunsen and Bennett methods are lengthy, and demand very careful manipulation. The permanganate titration is not as sensitive as the iodine, and the Krickhaus method offers no advantages in its application to arsenic acid over a similar reduction and titration with iodine. In other words, the iodine titration method (Mohr) seemed to us rather superior to any other in point of accuracy, manipulation and time, and was adopted for the work in view.

There are a number of processes that are noted more particularly as a means of eliminating impurities likely to effect the arsenic determination, among which may be mentioned the distillation processes of Fischer,[1] Piloty and Stock,[2] Stead,[3] and Jannasch and Seidel,[4] using hydrochloric acid in connection with reducing substances such as ferrous salts, hydrogen sulfide, and potassium bromide and hydrazine hydrochloride. The above list of methods is far from complete, but attention has been called to practically every type applicable to commercial products.

Iodine Method (Mohr).

As previously stated, the iodine method appeared to offer the greatest advantages, and was selected. A clear understanding of the character and limitations of the reaction underlying the method is necessary at the outset. Iodine is an indirect oxidizer, acting on the elements of water with the formation of hydriodic acid and the liberation of oxygen.

$$As_2O_3 + 4\ I + 2\ H_2O = As_2O_5 + 4\ HI.$$

The oxidation cannot be conducted in an acid or neutral solution because of the reversible action of the hydriodic acid. If the latter is neutralized with sodium bicarbonate as rapidly as produced, the reaction will proceed to completion. Caustic alkali or carbonate cannot be employed, as they absorb iodine, the former being especially active. The reaction between starch

[1] Ztschr. Analyt. Chem., 21, 266 (1882).
[2] Ber. Deut. Chem. Gesell., 30, 1649 (1897).
[3] Sutton, Vol. Anal., Edit. 9, 159 (1904).
[4] Ber. Deut. Chem. Gesell., 43, 1218 (1910).

and iodine in the presence of hydriodic acid or soluble iodide is one of the most sensitive in analytical chemistry, forming the characteristic blue iodide of starch. A more delicate indicator could not be desired. Since the method was first applied to the analysis of arsenicals numerous modifications have been devised to insure complete solution of the arsenic, to prevent oxidation, to eliminate or render innocuous substances that might effect the titration, and to enlarge its field of application so as to readily include the arsenates. The Association of Official Agricultural Chemists began work on insecticides in 1899 and has rendered valuable service.

New Processes.

The introduction of the Thorn Smith process [1] marked a turning point in the analysis of arsenicals. It was intended particularly for Paris green, and is the official method for that substance. Solution of the arsenic is effected by boiling the sample with a slight excess of sodium hydrate, which readily unites with the free arsenous acid, and also with the combined after displacing the copper. In presence of a reducing substance like sodium arsenite, the copper is precipitated as cuprous oxide and a portion of the arsenous acid oxidized to arsenic. This oxidation necessitates a subsequent reduction of the filtrate with hydrochloric acid and potassium iodide (hydriodic acid), and the removal of the excess iodine with thiosulfate. The solution is neutralized with dry sodium carbonate, an excess of sodium bicarbonate added, and titrated with iodine. The process is accurate, though the double titration is objectionable.

Avery and Beans devised a very ingenious process [2] noted for its simplicity. The Paris green is pulverized, solution effected with concentrated hydrochloric acid in the cold, neutralized with sodium carbonate, the precipitated copper redissolved with sodium potassium tartrate and titrated as usual. The copper held by the alkaline tartrate colors the solution but does not effect the titration. Hydrochloric acid, however, is a poor solvent for free arsenic, and unreliable, which constitutes a very serious objection to the process. Avery noted this error and advised [3] that samples showing a tendency to separate white

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[1] Jour. Amer. Chem. Soc., 21, 769 (1899).

[2] Jour. Amer. Chem. Soc., 23, 485 (1901).

[3] Jour. Amer. Chem. Soc., 25, 1096 (1903).

arsenic should be treated with N/2 hydrochloric acid, 5 to 10 cubic centimeters for each .1 of a gram, and boiled gently. In case arsenic remains undissolved, a cold saturated solution of sodium acetate, 3 grams salt for each .1 of a gram of substance, is added, and boiling continued until solution is effected. By another modification [1] suggested by Avery, and reported by Thatcher,[2] 1 gram sample is boiled five minutes with 25 cubic centimeters of sodium acetate solution (1–2), dissolving the free arsenic which is removed by filtration. The residue is dissolved in dilute hydrochloric acid and both solutions titrated.

Haywood attempted, in several ways,[3] to modify the original Avery-Beans process so as to insure solution of the free arsenic. After treating the sample with a slight excess of hydrochloric acid at laboratory temperature, sodium carbonate was added and the solution boiled. In another case sodium bicarbonate was employed, but the results were unsatisfactory in both instances, due to more or less reduction of copper and accompanying oxidation of arsenous acid. Accurate results were secured, however, by filtering off the hydrochloric acid solution and boiling the residue with 5 grams of sodium bicarbonate, titrating both solutions.

Haywood proposed still another modification [4] which might be considered a simplified Avery-Thatcher process; [5] .4 of a gram sample is boiled ten minutes with 25 cubic centimeters sodium acetate solution (1–2) to dissolve free arsenic, and concentrated hydrochloric acid carefully added until solution is effected. After neutralizing with a solution of sodium carbonate, avoiding an excess, alkaline tartrate and sodium bicarbonate are added and titrated as usual.

The Avery, Avery-Thatcher and Avery-Haywood processes employ the same reagents, differing only in their application. The co-operative investigation [6] of the association in 1904 showed that the three above modifications, together with the Haywood, gave closely agreeing results, with little, if any, advantage in the

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[1] Optional official method, Assoc. Off. Agr. Chem.
[2] Proc. Assoc. Off. Agr. Chem., 20, 196 (1903).
[3] Jour. Amer. Chem. Soc., 25, 963 (1903).
[4] Proc. Assoc. Off. Agr. Chem., 20, 197 (1903). Optional official method of the association.
[5] *Loco citato.*
[6] Proc. Assoc. Off. Agr. Chem., 21, 98 (1904).

two-solution processes over the one. In 1905 the results [1] with the Avery-Thatcher and Avery-Haywood modifications were not as satisfactory though the average difference was not excessive.

In weighing the merits of the Thorn Smith process and various modifications of the Avery-Beans, with apparently little choice as to accuracy, the Avery or Avery-Haywood process, with one titration of a single solution, certainly appeals to chemists in "control" work from the standpoint of manipulation, possible mechanical losses and time. This does not warrant any less care in conducting the analysis, but, if anything, demands greater attention. The essential features of the Avery-Haywood process have been employed at the Massachusetts station for the work on arsenites, though considerably modified as to detail.

Practice at Massachusetts Station.

Having adopted Thatcher's suggestion [2] as to ratio of sample to acetate solution, 1 to 25, and finding 25 cubic centimeters rather inadequate for proper boiling and agitation, double quantity of each is taken. To prevent slight loss of sample in transferring to flask, due to both adhesion and dusting, boats of folded filter paper are employed, and found very serviceable, particularly for Paris green and arsenic for standard solution. After boiling the solution five minutes with acetate, the directions call for the careful addition of concentrated hydrochloric acid until solution is effected. Such a procedure in our hands gave extremely variable results and generally a low test for arsenic. This error necessitated several weeks of experimenting, and was found to be due to the addition of *concentrated* acid, dilute acid (1–3) giving uniform results in practically every instance, and a higher test. Probably this has been one of the sources of trouble with the chemists reporting on association samples by the above process in past years. Neutralizing with sodium carbonate, in dry form or concentrated solution, will introduce an error if added in excess. The use of sodium bicarbonate is preferable for the purpose as the latter salt does not absorb iodine and eliminates an unnecessary reagent. As con-

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[1] Proc. Assoc. Off. Agr. Chem., 22, 27 (1905).
[2] Proc. Assoc. Off. Agr. Chem., 21, 99 (1904).

centration has a certain influence on titration, it is advisable to maintain approximately the same volume in every case. The tendency of some solutions to become muddy on titration can often be relieved by additional bicarbonate, though the conditions involved seem to have no appreciable influence on the results. The quality of all reagents employed in the determination should be proved by blank tests, which should not exceed .10 of a cubic centimeter iodine solution for the amounts employed. Some lots of bicarbonate have been found unfit for such work. Due recognition should be given the blank in calculating results.

Considerable trouble is often experienced in determining insoluble matter with hydrochloric acid, due to the splitting off of white arsenic, especially with Paris green. To offset the difficulty it was found advisable to combine the determination with that of preparing the arsenic solution by simply filtering off the residue. The points noted above may be briefly summarized: —

Transfer 2 grams of finely ground sample, together with 50 cubic centimeters of sodium acetate (1–2), to a 500 cubic centimeter graduated flask, and boil five minutes. Cool under tap, add about 60 cubic centimeters of hydrochloric acid (1–3), and shake until solution is effected. Make to volume and filter. Pipette 25 or 50 cubic centimeters into an Erlenmeyer flask, neutralize with dry sodium bicarbonate, add 25 cubic centimeters of sodium potassium tartrate [1] (1–10), to redissolve precipitated copper, approximately 3 grams of sodium bicarbonate, water sufficient to make a volume of 100 cubic centimeters, 2 cubic centimeters starch paste (1–200), and titrate with N/20 iodine to a permanent blue color. Toward the end of the reaction cork the flask and shake vigorously, to insure proper end point. Calculate results as arsenous oxide. The residue in the graduated flask is brought onto the filter, well washed, calcined in a porcelain crucible and weighed as insoluble matter.

The above process has given excellent results with copper aceto-arsenite, copper arsenite and calcium arsenite. Sodium acetate does not prevent hydrolysis of copper and calcium arsenites, as in the case of Paris green, but serves to take up free

[1] Used only with the copper arsenites.

arsenic. The presence of such impurities as cuprous and ferrous compounds, sulfurous and nitrous acids or other oxidizable substances is a source of error by the iodine titration method.

Iodine Method for Arsenates.

The increasing use of lead arsenate as an insecticide resulted in a demand for a rapid volumetric method for the determination of the arsenic acid. The Gooch and Browning process,[1] as modified by Haywood,[2] serves to readily reduce arsenic acid to arsenous, in which form the iodine titration method is applicable. The process in our hands did not at first prove satisfactory, but eventually yielded concordant results after minor changes. As the differences are largely a matter of detail, not involving principle, only the modified process will be given.

Transfer 2 grams of finely ground sample, together with 60 cubic centimeters of nitric acid (1–3), to a 500 cubic centimeter graduated flask; bring to boil, cool, make to volume and filter. Pipette 50 or 100 cubic centimeters into a 150 cubic centimeter Jena Griffin beaker, add 10 cubic centimeters of sulfuric acid (2–1), evaporate, heat in an air bath at 150–200° C. to expel last traces of moisture, and then on asbestos board, to the appearance of dense white fumes, to insure complete removal of nitric acid. Add a small quantity of water, and when cold, filter through a sugar tube under suction into a 300 cubic centimeter Erlenmeyer flask, and wash to about 150 cubic centimeters. Add 10 cubic centimeters of potassium iodide (165–1,000) and boil until *free iodine is expelled,* — solution practically colorless, — with the reduction of arsenic to arsenous acid.

$$As_2O_5 + 4\ HI = As_2O_3 + 4\ I + 2\ H_2O.$$

Dilute, cool immediately, neutralize approximately three-quarters of the free acid with 20 per cent. sodium hydrate solution, add starch paste, and if any free iodine remains, add dilute (N/50) thiosulfate carefully, with vigorous shaking, to the absence of blue color.

$$2\ I + 2\ Na_2S_2O_3 = Na_2S_4O_6 + 2\ NaI.$$

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[1] Amer. Jour. Sci., 40, 66 (1890).

[2] Proc. Assoc. Off. Agr. Chem., 23, 165 (1906). Provisional method of the association.

Make up to about 150 cubic centimeters, add excess of sodium bicarbonate and titrate as usual with N/20 iodine, reporting as arsenic oxide. The residue in the graduated flask is brought onto the filter, washed, calcined and weighed as insoluble matter.

Care should be taken to have sufficient sulfuric acid to cover the bottom of the beaker when heated on asbestos. A decided excess of acid is also necessary when boiling with potassium iodide to insure vigorous action and rapid volatilization of iodine. Undue concentration should be avoided. If free iodine persists add more water and continue the boiling. The use of caustic soda is permissible under the conditions described. The hydrate is a much more convenient and rapid agent than the carbonate. Practically no difference was noted in the titration when the lead sulfate was allowed to remain, but the data at hand do not cover a sufficient number of samples to warrant a statement that this will always hold true.

The iodine method, as modified for arsenites and arsenates, has been given a careful study, and proved repeatedly, in the work at the Massachusetts station, to yield excellent results in the analysis of the insecticides mentioned, if reasonable attention is paid in following the details. While no radical changes in the method have been recommended, this article is offered in hopes that some of the points noted may prove of assistance to other analysts working along similar lines.

PURIFICATION OF INSOLUBLE FATTY ACIDS.

BY E. B. HOLLAND.

Workers in oils and fats experience the same difficulty in obtaining chemically pure products as investigators in other lines of organic chemistry. The best insoluble fatty acids on the market — judging from our experience — are unsatisfactory in both physical characteristics and neutralization number. In general appearance the acids that are offered resemble granulated curd, though varying in color from white to yellow, and contain considerable dust and dirt. The molecular weight, as measured by titration in an alcoholic solution, may deviate from the theoretical by 10 to 15 points. These statements apply to chemicals marked " C. P." and bearing the name of a reputable manufacturer or dealer.

The writer required stearic, palmitic, myristic, lauric and oleic acids for certain tests, and, finding it impossible to purchase them of the desired quality, was forced to undertake a study of various methods for their purification. As the character of the unsaturated acids is so unlike that of the saturated, only treatment of the latter will be considered at this time. The methods that seemed the best adapted for the purpose were (*a*) distillation of the fatty acids in vacuo, (*b*) crystallization from alcohol, and (*c*) distillation of the ethyl esters in vacuo, and all were given extended trial.

A. Distillation of the Fatty Acids in Vacuo.

Direct distillation under reduced pressure was successfully employed a few years ago by Partheil and Ferie,[1] starting with Kahlbaum's best acids. Upon careful test the writer found that the method possessed certain objectionable features which render it rather impracticable for ordinary use. If it was merely a

[1] Arch. Pharm., 241, 545 (1903).

question of distillation of the acids the process would be less difficult, but for fractionation, using a Bruehl or similar type apparatus, it proved almost impossible, in case of the higher acids, to prevent solidification in the side neck (outflow tube). The danger arising from a plugged apparatus at the high temperature involved has also to be taken into account. An attempt was made to heat the tube and keep the acids liquid by means of a hot-water jacket, also by an electrically heated asbestos covering, but neither process fully met the requirements of the case. The slow distribution of heat in vacuo is, of course, one of the obstacles in the way. For the distillation of solids of high melting point Bredt and A. van der Maaren-Jansen[1] devised an elaborate piece of apparatus having a flask and receiver of special construction, and an overflow tube heated by electricity, but it is hardly suited for a general laboratory or for handling any considerable quantity of material.

There are two other conditions necessary for a successful distillation of fatty acids, namely, absence of moisture and a current of hydrogen or carbon dioxide to prevent bumping and to lessen decomposition. Overlapping of the acids in different fractions cannot be obviated entirely, and if an unsaturated acid was present in the original, it will probably appear in nearly every fraction.

Students under the direction of Professor Burrows of the University of Vermont have applied this process for a partial separation of the insoluble acids of several oils with a fair measure of success. With all due allowance for the possibilities of the method in the production of pure saturated fatty acids, the inherent difficulties render it inadvisable in most instances.

B. Crystallization from Alcohol.

Crystallization in this connection is practically limited in its application to the removal of a small amount of impurities, especially unsaturated acids. It can hardly be considered other than a supplementary treatment, though excellent for that purpose, to follow either of the distillation methods. Dry neutral alcohol suitable for such work can be prepared by distillation after treatment with caustic lime. In dissolving the acids care

[1] Liebig's Ann. Chem., 354, 367 (1909).

should be taken to avoid heating to a higher temperature than is required for solution, or to prolong the heating unduly, as it will cause the formation of esters. Several minutes' boiling of the different fatty acids in alcohol caused the following loss in neutralization number: —

Stearic acid,	1.70
Palmitic acid,	.56
Myristic acid,	2.24
Lauric acid,	.89
Oleic acid,	.28

Esterification undoubtedly causes a serious error by this process of purification. Under more careful treatment the change is not as rapid as shown above, but is evidently cumulative and may even exceed the figures given. Further study may warrant the substitution of a more stable solvent, such as acetone. For the filtration a water or ice jacketed funnel is almost necessary, particularly for the acids of low melting point, and suction is a time saver. Repeated crystallization is needed to bring out the true crystalline structure and silvery luster of the leaflet. Vacuum drying at a low temperature is one of the most efficient means for removing adhering alcohol and traces of moisture without injuring the structure. Crystallization as a whole is wasteful of acids and solvent unless both are recovered, but is essential for the production of a superior product.

C. Distillation of the Ethyl Esters in Vacuo.

As ethyl esters distill freely in vacuo, the process admits of a more ready application, and to products of a greater range of purity, than does a distillation of the acids. After considerable experimenting it was found that the esters are easily prepared by heating in an open flask equal parts (100 grams) of fatty acids and alcohol, together with a small quantity (10 cubic centimeters) of concentrated hydrochloric acid, using capillary tubes to prevent bumping. The reaction requires about thirty minutes, after which the excess of hydrochloric acid can be removed with a separatory funnel. The distillation is conducted in a 500 cubic centimeter "low" side neck flask, with a small (8 inch) Liebig condenser and a large size Bruehl frac-

tionation apparatus. Heat is furnished by means of a linseed oil bath, and suction by a pump of any type, using a mercury manometer to prove constancy of vacuum. The neck of the flask from the shoulder to an inch or more above the side tube should be wound with asbestos paper to prevent cracking, due to sudden changes of temperature. The condenser should be kept full of water, without circulation, to serve as a hot-water jacket. The vacuum should be as high as the flask will safely withstand, but above all uniform, otherwise the fractions are of questionable value. The temperature range of an ester also varies with the distance between surface of liquid and side tube. At least one redistillation of like fractions is necessary.

As the esters are very stable, more difficulty was experienced in finding some means for their quantitative decomposition than in any other portion of the work. Heating with mineral acids hydrolizes the fatty acids very slowly, even under pressure. If, however, the esters are first saponified [1] by heating over a naked flame with twice their volume of glycerol and an excess of caustic potash until all the alcohol is expelled, and then the resulting soap dissolved in water and heated on a water bath with a slight excess of sulfuric acid, the separation is readily accomplished. This plan was suggested by the Leffmann-Beam saponification for volatile acids, and after extended trial proved the most thorough and rapid means for decomposing the esters. The resulting acid should be washed in a separatory funnel with boiling water until clear, and the cake allowed to drain. As previously stated, several crystallizations are necessary if a crystalline product of satisfactory melting point and neutralization number is to be secured. When crude acids are employed it is also advisable to crystallize at the outset to exclude a major part of the unsaturated acids, which otherwise would prove troublesome.

To summarize: saturated fatty acids may be purified by distillation of the acids or their ethyl esters. The latter method is less hazardous and easier to manipulate, although more steps are required. Crystallization is a finishing rather than an initial process of purification.

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[1] Observing the usual precautions given for the determination of insoluble fatty acids, Massachusetts Agricultural Experiment Station, twenty-first report, p. 130 (1909).

THE SOLUBLE CARBOHYDRATES IN ASPARAGUS ROOTS.

BY FRED W. MORSE.

This paper is a simple statement of progress in a study of the composition of the asparagus plant, and is part of an investigation of the fertilizer requirements of asparagus now being conducted at this agricultural experiment station.

The nutrition of asparagus shoots in early spring necessarily depends on the material stored in the roots, since the mode of growth of the young shoots up to the time of cutting for the table renders assimilation from the atmosphere nearly impossible. Hence, roots were selected as the first portion of the plant to be studied.

A search of the literature of asparagus failed to show anything about the composition of the roots beyond a few scattering ash analyses and a brief article by Vines [1] on the reserve proteins.

Very recently, however, Wichers and Tollens [2] have reported an extensive study of asparagus roots, and called attention to similar work by Tanret,[3] brief abstracts of whose articles had been overlooked.

Since the work has been wholly independent of that just mentioned, it is believed that this report of progress will be of value at this time.

All the material for the work here reported was prepared in other divisions of the department, and consisted of finely pulverized samples of individual root systems. All of the plant below the surface had been dug up, freed from earth and dried

[1] Proc. Royal Soc., 52, 130–132; Abstr. Jour. Chem. Soc., 64, 431.

[2] Jour. f. Landwirth., 58, 101–116.

[3] Bul. Soc. Chem. (4), 5, 889, 893; Compt. Rend., 149, 48–50; Abstr. Jour. Chem. Soc. (1909), Abstr., 634; Chem. Abstr., 3, 2677.

at about 50° C. The roots were secured in November of the second year after setting, when translocation from the tops was believed to be complete. For subsequent study of the effects of different fertilizers the individual samples were separately analyzed; but for this report detailed results are unnecessary.

The average proximate composition of the dry matter of 16 roots was as follows: —

	Per Cent.
Protein (nitrogen x 6.25),	11.03
Fat,	1.00
Fiber,	15.39
Nitrogen-free extract,	66.34
Ash,[1]	6.24

The proximate composition showed clearly that the soluble non-nitrogenous matter included most of the reserve material of the roots.

The methods of the Association of Official Agricultural Chemists [2] for sugars, starch, pentosans and galactans were employed for estimating the different carbohydrates in the reserve material.

An examination of 25 roots showed 12 to contain no reducing sugars, while most of the others had only traces present; therefore reducing sugars were not estimated, but were reckoned with total sugars. The latter were especially abundant, and ranged from 26.4 per cent. to 50.8 per cent., only two samples containing less than 35 per cent. calculated to dry matter.

Pentosans were determined in 16 samples, and ranged from 7.32 per cent. to 10.68 per cent. in the dry matter. Galactans were determined in 4 individual samples and in a composite sample, but were insignificant in amount, averaging only 1.04 per cent.

In the estimation of starch by the diastase method, it was found that there was no more glucose obtained than was accountable from the diastatic extract. Subsequent examination revealed starch in only microscopic traces. Six different samples, after having undergone the diastase treatment as for starch,

[1] Ash determinations were made in the fertilizer division of the department.

[2] Bulletin No. 107, Bureau of Chemistry, United States Department of Agriculture, pp. 38–56.

were filtered and washed, and the residues then subjected to two hours' boiling under reflux condensers, with 100 cubic centimeters of HCl of approximately 6 per cent. After cooling the solutions they were nearly neutralized with NaOH, and made up to 250 cubic centimeters. The reducing sugars were then determined by Fehling's solution and the weights of copper calculated to glucose. The 6 samples averaged 8.6 per cent. of glucose by this hydrolysis; but since the same samples averaged 8.67 per cent. of pentosans, reckoned from furfurol-phloroglucid, it is improbable that there are any hydrolizable carbohydrates unaccounted for by the usual analytical methods.

From these different analyses it was found that the dry matter of 16 roots contained —

	Per Cent.
Sugars calculated as invert sugar,	41.43
Pentosans,	8.78
Galactans,	1.04

The carbohydrate forming over 40 per cent. of the dry matter was at first assumed to be sucrose. The analytical procedure had shown it to be soluble in cold water and inactive to Fehling's solution until hydrolized, which was easily accomplished by dilute acids. Repeated attempts to recover sucrose by means of strontium hydrate [1] resulted in securing only very small quantities of a straw-colored syrup which could not be crystallized, but did not reduce Fehling's solution.

Methyl alcohol was found to extract considerable quantities of the sugar from the roots, which suggested raffinose; but no mucic acid could be obtained by oxidation with nitric acid, although a parallel test with lactose under the same conditions yielded it in abundance.

Osazones were prepared from both methyl alcohol and water extracts, before and also after inversion. The characteristic yellow, crystalline precipitate was easily obtained in every case. Five such precipitates had their melting points determined, and they ranged between 203 ° and 210 °, and were accompanied by an evolution of gas. Glucosazone was evidently the only one formed.

[1] E. Schulze, Zeitschr. Physiol. Chem., 20, 513–515.

About 100 grams of roots were extracted by cold water and the extract concentrated on the water bath to a thick, black, tenacious syrup, which was strongly reducing to Fehling's solution. Heat and probably acid salts had brought about a nearly complete hydrolysis during the evaporation. This extract failed to yield mucic acid, but oxalic acid was readily formed.

Portions of the syrup were subjected to distillation with HCl of 1.06 specific gravity, and yielded a small quantity of furfurol. The furfurol-phloroglucid, after being dried and weighed, was found to lose about two-thirds of its weight by solution in hot 93 per cent. alcohol, indicating that it was largely methyl-furfurol.

The action of polarized light was observed upon freshly prepared water extracts of two different roots, and upon three syrups which had been fractionated by strontium hydrate. The solutions were clarified by lead subacetate, and the readings were made in a Schmidt and Haensch triple shade saccharimeter through a 200 millimeter tube. The solutions were then inverted and again polarized, together with two solutions of the dense water extract above mentioned.

Subsequent to the readings, the actual strength of sugar in each solution was determined with Fehling's solution. The solutions were necessarily dilute, because the roots on moistening swelled to a large volume and small charges had to be used. The three syrups were small in amount, as before mentioned, and the black syrup from the water extract was difficult to clarify to a point where light would pass through it.

Polarization before Hydrolysis.

	Sugar in 100 Cubic Centimeters (Grams).	Saccharimeter Reading.	Specific Rotatory Power (Degrees).
Root 34,	1.738	+0.5	+5.0
Root 40,	2.259	−1.4	−10.0
Syrup A,	2.623	+2.88	+18.9
Syrup B,	2.775	−1.6	−10.0
Syrup C,	.858	zero	zero

Polarization after Hydrolysis.

	Invert Sugar in 100 Cubic Centimeters (Grams).	Saccharimeter Reading.	Specific Rotatory Power (Degrees).
Root 34,	.893	—2.33	—45
Root 40,	1.189	—4.10	—59
Syrup A,	1.381	—3.45	—49
Syrup B,	1.461	—5.25	—62
Syrup C,	.452	—1.30	—49
Extract 1,	.936	—3.00	—55
Extract 2,	2.350	—7.80	—57

The action on polarized light both before and after inversion excludes the possibility of the carbohydrate being pure sucrose, while the failure to secure it with strontium hydrate renders its absence probable.

Fructose was clearly demonstrated by the osazone and the negative optical activity, also by fine reactions with resorcin and hydrochloric acid. Glucose is indicated by the osazone and the fact that the specific rotatory power of the inverted solutions is not high enough for pure fructose. Fructose clearly predominates over the glucose, and the non-reducing property before hydrolysis indicates some condensation product formed between them. The behavior of individual root extracts does not point to any fixed proportion of the two sugars.

These results are, on the whole, in close agreement with those of Wichers and Tollens. There was, however, a marked difference in the behavior of the water extract of the roots, which contained the sugar-like carbohydrate. Wichers and Tollens used boiling water, and state that only a portion of this carbohydrate was soluble in water when extractions were made on the water bath. Their solutions also reduced Fehling's solution before hydrolysis.

My extractions were all made with water at 20° C., and until hydrolized, had either no reducing action or precipitated no more than traces of copper.

This difference in solubility and reducing action is doubtless

due to the stage of development of the roots, since Wichers and Tollens worked upon roots gathered in April and July instead of in November.

Tanret isolated two distinct crystalline carbohydrates from the root sap, one of which had a rotation of — 35.1 and the other + 30.3. Syrups A and B fractionated with strontium hydrate showed opposite rotations before inversion, but lack of material has given no opportunity to confirm further his observations.

Grateful acknowledgment is made of suggestions received from Dr. Joseph B. Lindsey during the progress of this investigation.

SEED WORK, 1910.

BY G. E. STONE.

The seed work for 1910 includes seed germination, separation and the testing for purity. The number of samples of seed sent in for germination exceeded that of 1909, the total number being 296. This germination work seems to be on the increase from year to year, and a great many more varieties of seed are tested for germination than has been the case in the past. Of the total number of samples sent in this year, 152 were miscellaneous seeds, a trifle over 50 per cent. of the total number. The number of samples of onion seed sent in was a little less than in 1909, and tobacco averaged about the same. The average germination of the tobacco seed, 95 per cent., was slightly better than usual. The lowest germination of any sample of tobacco seed sent in was 89 per cent. On the whole, onion seed last year did not seem to be up to the previous year's standard, as the average germination of all samples was only 77.4 per cent., as against 82.2 per cent. in 1909. The germination of the tobacco seed, with a lowest percentage of 89, tends to prove the theory that large seeds produce large plants; therefore in succeeding years better crops are obtained, and, as a result, better seed.

TABLE 1. — *Records of Seed Germination, 1910.*

Kind of Seed.	Number of Samples.	Average Per Cent.	Per Cent. of Germination.	
			Highest.	Lowest.
Onion,	75	77.4	100.0	3.0
Tobacco,	7	95.0	99.0	89.0
Lettuce,	41	77.7	100.0	15.0
Cucumber,	10	93.7	99.0	85.0
Alfalfa,	4	98.2	100.0	97.0
Clover,	4	93.0	97.0	88.0
Red clover,	3	100.0	99.5	98.5
Miscellaneous,	152	66.0	100.0	–
Total,	296	–	–	–

The work in seed separation for 1910 was carried on as usual, and although a smaller number of samples was separated than in 1909, the total amount of seed separated, 1,552 pounds, was greater. Of this, 1,183 pounds were onion seed. The principal varieties of seed separated were onion, tobacco and lettuce. The separation of onion seed also tends to show that the seed was not as good this year as it was in 1909, as the average percentage of good seed was only 88.7 per cent., while the amount of discarded seed was slightly larger than in 1909. As in years past, several growers have requested that this station test the germination of seed both before and after separation, and the results this year resemble those of previous seasons so closely that they will not be inserted in this report. In the case of the separation of lettuce seed, the grower sending the seed often requests that a certain amount, sometimes in excess of the actual need, be taken out. This, however, is believed to be a good practice in the case of lettuce or tobacco seed, as it is certain that better germination results from removing more than is absolutely necessary. Table 2 shows the records of seed separation for 1910.

TABLE 2. — *Records of Seed Separation, 1910.*

KIND OF SEED.	Number of Samples.	Weight (Pounds).	Per Cent. of Good Seed.	Per Cent. of Discarded Seed.
Onion, ...	40	1,183.82	88.7	11.3
Tobacco, ...	62	44.96	89.6	10.4
Lettuce, ...	13	323.45	74.4	25.6
Total, ...	115	1,552.23	-	-

No effort has been made on the part of the station as yet to establish and maintain a seed-control laboratory for the purpose of testing the purity of seed, and therefore in the past year the number of samples of seed sent in for examination as to their purity has been small. In all, some 30 samples have been examined; mostly clovers and grasses, but as this work takes considerable time, no grass mixtures have been examined for purity.

The station is always glad to receive samples of seed for germination, and it is believed that if the farmer would send his seed in for examination for purity also, he would very often save himself a great deal of trouble and expense, as much of the seed sold in this State is full of weed seeds. It is believed that there should be a seed-control act in Massachusetts, as has been stated in our previous reports, and the sooner this comes the better the farmer will be served by the seedsmen, since they are perfectly willing to handle good seed if it is what the farmer wants and demands.

All samples of seed to be germinated or separated should be addressed to G. E. Stone, Massachusetts Agricultural Experiment Station, Amherst, Mass., and the express or freight on these seeds should be prepaid.

AN OUTBREAK OF RUSTS.

BY G. E. STONE.

For the past three years certain rusts have increased materially in this State as well as in other sections of the United States. The rust on the apple, which has been scarcely noticeable for years, at least on our cultivated fruit trees, has become quite common the last three seasons. It was particularly prevalent three years ago, and quite a little of it has been noticed on apple leaves the past two years. The hawthorne (Cratægus), a plant closely related to the apple, has shown a much greater tendency to rust in the period above mentioned than formerly, and some anxiety has been felt by nurserymen who have had to contend with this in their nurseries.

The ash rust, which is supposed to have as one of its hosts the grass known as Spartina, has occurred much more commonly than usual during this period. It is to be found on young growths of ash trees, distorting the twigs. There have also been severe outbreaks of the bean rust lately, although this has given little trouble in former years; and the hollyhock, rose and quince rusts have been much more common than formerly.

SWEET PEA TROUBLES.

BY G. E. STONE.

One of the most unsatisfactory types of troubles with which the pathologist has to deal is that having no specific organism as its primary cause. It is especially difficult to diagnose such diseases where the conditions of growing the plants are almost entirely unknown, and this is the case with most of the miserable, sickly looking sweet pea plants sent into the laboratory for diagnosis. There may be well-defined troubles associated with sweet peas, but from 90 to 100 per cent. of them may be prevented if the grower has even an elementary knowledge of the conditions required by this plant.

When sweet peas are planted in poor soil, without care or preparation, unfavorable results may be looked for. That such is too often the case is evident from an examination of the material which is sent in for examination. To obtain a good crop of sweet peas unusual care should be given to preparation. A light soil is better than a heavy, compact soil. It is impossible to grow this crop without a good depth of garden loam, and, if this is not available, it must be secured by deep trenching and heavy manuring. Most skillful gardeners maintain that the best results are obtained by having a soil which the sweet pea roots can penetrate deeply, and in which they can develop luxuriantly. A trench 1½ to 2 feet deep and the same width, filled with manure and loam, is usually sufficient. If a good depth of root development is desired, it is best to sow the seeds in trenches 4 to 6 inches below the surface, and as the plants mature the soil can be gradually hoed around the stems. The many specimens which we receive from growers testify to the poor conditions in which the plants have been grown, there being little root or stem development, and often tubercles on the roots are lacking. Proper conditions count very much in growing sweet peas, and when these are given, many so-called "diseases" peculiar to this plant disappear.

A SPINACH DISEASE NEW TO MASSACHUSETTS.

BY HARRY M. JENNISON, B.S.

Early in the spring of 1910 the writer's attention was attracted to a plot of winter spinach growing on the college grounds which had been practically ruined by a fungus causing a spotting of the leaves. The olivaceous color of the spots on the diseased leaves suggested the possible presence of a Cladosporium as the causal organism, but upon microscopical examination the fungus was determined to be *Heterosporium variable,* Cke. This organism is closely related to that causing the *Heterosporium* disease of cultivated carnations, known as "fairy ring."

It was supposed that a disease which could so completely devastate this crop would have been extensively reported, but upon thorough search of the literature only a few references to this particular spotting of spinach could be found. In 1905 Clinton [1] reports having collected in the open market in New Haven, Conn., specimens of spinach leaves affected with the above-mentioned fungus, and he refers to it as "leaf mold." Halsted [2] in his investigations on the fungi attacking the spinach plant does not include *Heterosporium* in his list. Since 1908 Reed [3] has been studying its occurrence and injurious effects in the truck crop regions of Virginia, where it causes large losses annually to the truck farmers of that State. At Amherst the disease was found infecting winter spinach, growing on two widely separated plots. Immediately adjacent to one of these was a considerable area set with young spinach

[1] Clinton, G. P., Connecticut Agricultural Experiment Station, report for 1905, Part V., p. 275.

[2] Halstead, B. D., New Jersey Agricultural Experiment Station Bulletin No. 70, 1890.

[3] Reed, H. S., in Virginia Agricultural Experiment Station circular No. 7, revised edition, p. 80, 1910.

Showing *Heterosporium* Disease of Spinach.

plants for the late spring crop. Careful examination, however, failed to reveal any indications of this disease on the young plants. As has been suggested, this fact seems to indicate that the causal organism is not a true parasite, and that it cannot infect healthy, vigorous plants, being more probably one that is capable of infecting its host only after the latter has become weakened by adverse climatic conditions, or injuries produced by other causes.

Further observations upon this interesting phase unfortunately could not be made, but in a recent text-book on the "Diseases of Economic Plants"[1] the following statement is found: "The disease does not seem capable of attacking healthy, vigorous plants, but usually follows injuries produced by other agencies."

The first indications of the presence of the disease are subcircular areas of dead tissue from 1/8 to 1/4 of an inch in diameter and brownish in color. (See cut.) These spots soon become more noticeable by the development of a greenish-black felt of fungous mycelium, bearing conidiophores and conidia, on both the upper and lower sides of the leaf. The spots are frequently more numerous toward the apex of the leaf, and by the time the fungus felt is well developed, the intervening leaf tissue is yellowed and presents a sickly appearance. Often the leaf is so badly infected that the diseased areas coalesce, leaving very little of the leaf tissue visible.

The market value of the crop is lessened if the leaves are at all spotted, and when badly diseased it is not salable. Even if the whole plant does not collapse from the effects of the fungus, it is greatly injured, and trimming off the injured leaves necessitates extra labor and expense at harvest time.

Since the disease is new to this locality, and there have been such limited opportunities to study it and the factors responsible for it, it is impracticable to offer any remedies at present. If the disease is sporadic, and caused by adverse conditions, the proper remedy would be to find out what those conditions are and remedy them. On general lines, however, it would be well

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[1] Reed, in Stevens & Hall's "Diseases of Economic Plants, — Heterosporiose," p. 288, 1910.

to employ sanitary methods in growing the crop, to use seed from healthy and vigorous plants, and try to prevent injuries from insects, etc.

ADDITIONAL REFERENCES.

Reed, Science, n. s., Vol. 31, p. 638, 1910.
Cooke, Grevielea, Vol. 5, p. 123, 1877.
Tubeuf & Smith, "Diseases of Plants," p. 516, 1897.
"Market Gardener's Journal" (Louisville, Ky.), Vol. 7, No. 5, 1910.

ABNORMALITIES OF STUMP GROWTHS.

BY GEORGE H. CHAPMAN.[1]

For the past few years there have been called to our attention on stump land and burned-over wood lots various malformations and abnormalities of the leaves of sprouts growing from the stumps; and in connection with other physiological work being done in the laboratory,[2] these conditions were studied, with the idea of discovering, if possible, the cause and relationship to other physiological diseases, such as those arising from malnutrition; also mosaic disease, overfeeding and œdema.

These diseases are all different in character, but it might be well to give a brief description of them at this point.

Overfeeding, particularly with nitrates, may be recognized by a slight increase in size of leaf, the color being darker and the leaf stiffer in texture. The cells of the leaf, with the exception of the bundles, are normal in form and are larger, but the bundles are distorted, and this causes a distortion of the leaf, due to the form of the bundles. The leaf is usually somewhat larger than normal, and the distortion curves the edges of the leaf downward, *i.e.,* rolls them toward the under side.

All investigators agree that the mosaic disease is purely a physiological one, but there seems to be much doubt as to whether it is infectious or contagious in character, or both. There seems to be some difference in opinion, also, as to the direct cause of the disease. In tomatoes it is always produced when the vines are heavily pruned, and in the work here it has been shown that it is connected in no way with methods of transplanting the young plants, and only results from subsequent pruning.

It has been found that tobacco is much more susceptible un-

[1] Presented as part work for degree of M.Sc.

[2] Dept. of Veg. Phys. and Path., Mass. Agr. Exp. Sta.

der conditions which tend to produce the disease than is the tomato.

In the case of tobacco, A. F. Woods[1] found that when a plant was grown in soil containing small roots of diseased plants the disease occurred in a short or long period of time, as the case might be. In our observations on the tomato we have been unable to verify this statement, as in no case has the disease appeared when normal plants were grown in soil which contained roots of plants which had been badly diseased, and in the growing of tomatoes year after year in the station greenhouses there has never been the slightest evidence of infection arising from the soil.

In the case of the tomatoes grown under glass, the disease did not make its appearance when the plants were left normal, but occurred when the plants were pruned. These conditions held true for soils in which there were diseased roots as well as for those in which tomatoes had not previously been grown.

The appearance of mosaic disease has been described by many investigators, and nearly all have described it in a similar manner, but more particularly with reference to tobacco than to the tomato. The general characteristics of the disease are the same for both plants, but some difference is found in its appearance in extreme cases on the tomato, as will be noted from the following description.

In the first stages of the disease the leaf presents a mottled appearance, being divided into larger or smaller areas of light and dark green patches. At this point, however, no swelling of the areas is noticeable, but as the disease progresses the darker portions grow more rapidly, while the light-green areas do not grow so rapidly, and leaf distortion is brought about. In the case of tomato, the light-green areas become yellowish as the disease progresses, and in badly affected plants become finally a purplish red color. This purplish coloration is found principally on plants which are exposed to strong light, but does not always occur, as it has been found that sometimes, even in badly infested plants, the disease may reach its maximum without showing any reddish coloration whatever. The reddish

[1] U. S. Dept. Agr., Bur. of Plant Ind., Bul. No. 18.

appearance is noticeable only on the upper surface of the leaf, and appears to extend only through the palisade cells. As yet no investigation has been made with reference to its character, but from its appearance under the microscope it is thought that it may be due to the breaking down of the chlorophyll granules as a result of the diseased condition of the leaf.

Under all conditions of disease, however, the leaves are much distorted and stiff, and often very badly curled, usually with the edges rolled up over the leaf, and never possessing the flexibility of healthy, normal leaves.

Œdema is perhaps the least liable to be confounded with other physiological troubles as its appearance is more strongly characteristic. Only a brief description will be given here, as this trouble does not enter into the discussion in this paper. Usually the leaves, as a whole, hang pendent, but the leaflets curl strongly upward; on close examination it is found that the veins, midrib and surface of the leaf show elevated more or less frosty areas, somewhat resembling the masses of conidia of some of the Erysyphæ; although in mild cases this condition is not striking, but the leaves usually have a more or less pearly luster at some stage of its development. The epidermal cells are very much enlarged in these areas and turgid, and the chlorophyll-bearing cells are also greatly changed. For a detailed description and discussion of this trouble no better work can be found than that of G. F. Atkinson.[1]

It can be seen from these brief descriptions that unless care were exercised it might be easy to confound these troubles, especially in the case of the first two. Keeping this in mind we will pass on to a more detailed description of the malformation of stump growth subsequent to the burning off or cutting down of large trees.

The malformation appears to be worst in the first two or three seasons' growth, the sprouts outgrowing the trouble as their age increases. From our observations this trouble appears to occur in two distinct forms: first, as an abnormal growth of stem and leaves, they sometimes reaching a size five to ten times that of normal young plants of the same species. This form of the

[1] N. Y. (Cornell Univ.) Agr. Exp Sta., Bul. No. 53, "Œdema of Tomato."

leaf was especially noticeable in such sprouts as ash, poplar and plane tree, and sometimes occurred also on chestnut and oak, although it may be mentioned that they were occasionally very much distorted.

When the leaves were simply abnormally large it was found that the structure of the cells and their relative positions were analogous to a healthy, normal leaf, but that they were relatively much larger, and were of a stiffer texture than the normal specimens.

Very often it was found that the cell contents, especially the coloring matter, were brought into undue prominence, richly colored red leaves being of frequent occurrence. Occasionally, also, leaves having a decided yellow color, but otherwise appearing strong and healthy, were observed. This excessive coloration was evidently due to the abnormal deposition of pigment or activity of colored cell sap. When the leaves were green, the color seemed to be deeper than that of normal specimens.

The second form of the malformation has much the appearance of that caused by overfeeding, or excessive use of nitrates; *i.e.,* a severe distortion of leaves, but in this case accompanied by excessive production, usually smaller in size than the normal, but thickly clustered. Distorted leaves did not usually show much abnormal coloration, but occasionally a reddish or yellowish color was observable.

Usually the leaves were much more numerous and very badly distorted, the veins and ribs being especially twisted in various ways. The texture of the leaf was very stiff, much more so than in the case of the abnormally large leaves, the tissue having hardly any elasticity, and breaking easily, with a crackling sound. Plates I. and II. (Figs. 1, 2 and 3) show the two forms of this trouble better than mere description.

There is a remarkable dearth of literature bearing on this specific trouble, although much has been written in a general way on somewhat similar physiological troubles, but dealing principally with field crops and forced plants. In the reports of the various experiment stations will be found more or less literature on physiological troubles, and Woods,[1] Suzuke,[2] Stur-

[1] U. S. Dept. Agr., Bur. Plant Ind., Bul. No. 18.

[2] Bul. Col. Agr., Tokyo, Vol. IV., repts. for 1900.

FIG. 1.—Chestnut (*Castanea dentata*), showing Diseased (Left) and Healthy (Right) Shoots.

FIG. 2.—Red Oak (*Quercus rubra*), showing Diseased (Left) and Healthy (Right) Shoots.

PLATE I.

FIG. 3.—Poplar (*Populus grandidentata*), showing Diseased (Right) and Healthy (Left) Shoots.

FIG. 4.—Mosaic Disease on Tomato.

FIG. 5.—White Oak, showing Diseased Shoot.

PLATE II.

PLATE III.

FIG. 1.—Mature pycnidia, showing a few unicellular hyaline spores and orifice from which they have been expelled.

FIG. 2.—Nearly mature pycnidia, with attached *Alternaria* spores.

FIG. 3.— Mycelium threads giving rise to *Alternaria* spores and an immature pycnidium.

FIG. 4.—Common type of *Alternaria*.

FIG. 5.—Conidial form of *Cladosporium* developed from microsclerotia found on gummy excretions.

All from camera lucida drawings.

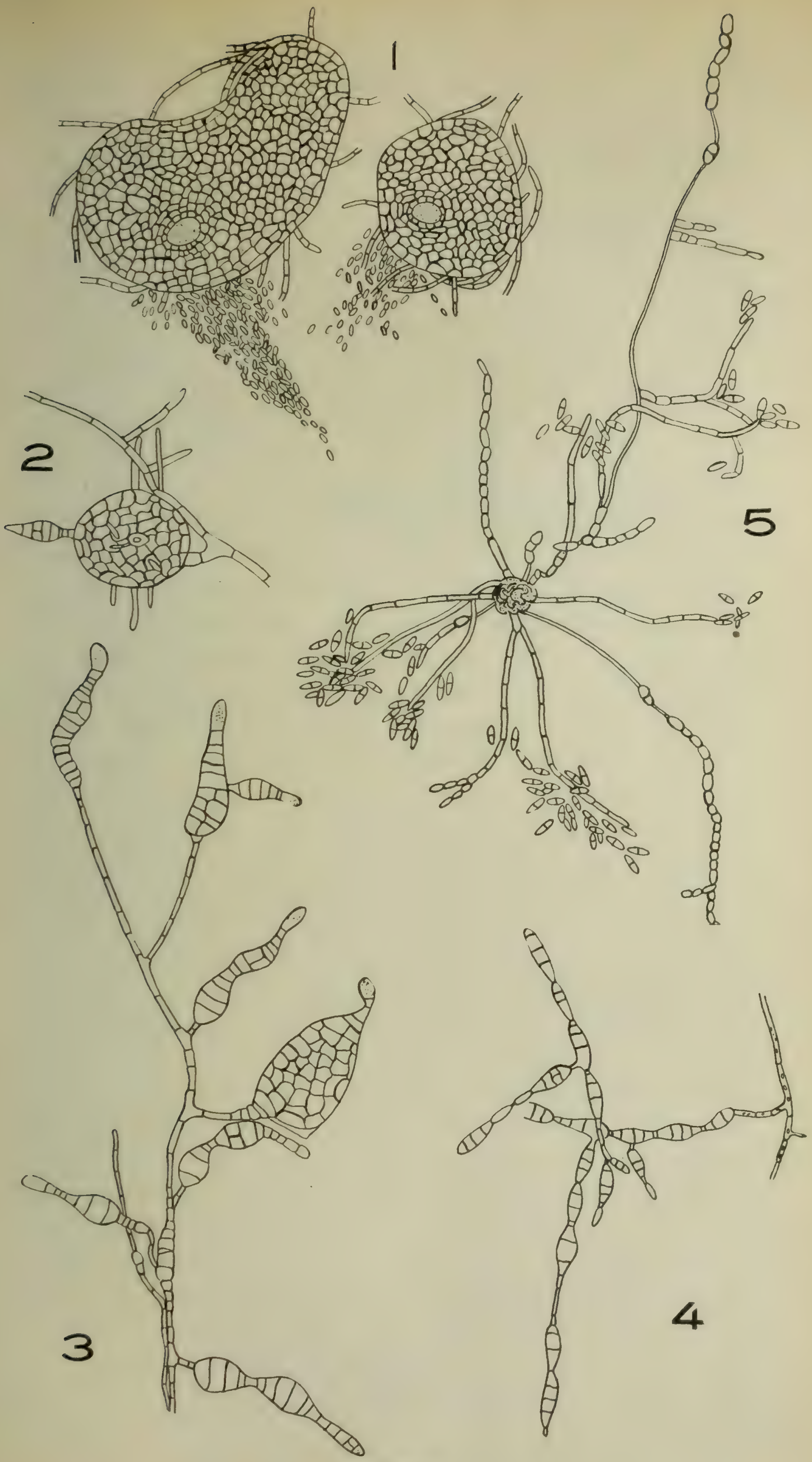

PLATE III.

gis,[1] Czapek,[2] Stone,[3] Atkinson [4] and others have dealt with various physiological troubles more in detail.

From our observations and experiments in the field and greenhouse we have come to the conclusion that it is a well-developed form of malnutrition, using malnutrition in its broadest meaning, *i.e.*, to include any physiological trouble which is caused by an excess or lack of any one or more nutritive substances necessary for the normal metabolism of a plant, and is allied to the phenomena exhibited in a severe case of overfeeding.

Logically it is what one would expect when a large tree is suddenly cut off or the top killed, and practically all transpiration, respiration, or, in short, all photosynthesis and leaf metabolism, is suddenly arrested. We have a violent disruption of the normal metabolism of the tree. The balance between root absorption, photosynthesis, etc., and the metabolic processes of the leaves is suddenly broken, and we have the roots, which are still alive, attempting to do their normal work without the aid of the leaves; starch formation is arrested and carbon assimilation cannot take place. In the roots there remains a great reserve store of food and during the winter no root pressure. As most woods are cut in the fall and winter, the trees are dormant, and forest fires also occur largely in fall and spring during this dormant period. Now, when spring comes and circulation starts, the adventitious buds are called upon to produce new shoots for the utilization of the reserve food in the roots. This they try to do in the manner we have described, by producing abnormally large leaves or a great number of small and distorted leaves. This distortion will be discussed later.

Of the trees which have come under our observation, maples, oaks and chestnuts seem to be the most susceptible to leaf distortion, while such trees as the ash, poplar and plane usually have abnormally large leaves with very little distortion. However, in some cases both conditions are observable.

The theory which has been advanced above as to the cause of the disease has been borne out by experiments carried on in the

[1] Conn. Agr. Exp. Sta., 1898, and others.
[2] Biochemie der Pflanzen (general).
[3] Mass. Agr. Exp. Sta. reports.
[4] N. Y. (Cornell Univ.) Agr. Exp. Sta., Bul. No. 53.

field and laboratory. The results of these experiments will be discussed later in the paper.

Relation to Mosaic Disease.

It was at first thought that there might be some relation between the so-called "mosaic disease" and this, but from our observations we have been able to find only a superficial relationship, *i.e.*, as regards the distortion of the leaf in its first stages. Other investigators,[1] as has been previously mentioned, have proved that the "mosaic disease" can be communicated from one plant to another by inoculating a healthy plant with the juice of a diseased plant, and that the new growth subsequent to the inoculation will come diseased in nearly every case. This is not so in the case of sprout growth, however, as in no instance were we able to bring about a diseased condition of normal plants by inoculating them with juice taken from diseased leaves. As it was impossible to carry on these inoculation experiments in the laboratory, the work was done in the field, and observations taken from time to time.

Experiments in Inoculation.

In order to prove that, unlike mosaic disease, this malformation could not be communicated from a diseased sprout to a healthy one, the following experiments were made. Two series of ten inoculations each were made; in one case diseased tissue was inserted at the base of the terminal bud of normal, healthy sprouts; in the second series the terminal buds of healthy sprouts were inoculated with the filtered juice from diseased plants. In all cases a healthy plant was inoculated with the tissue or juice of a malformed plant of the same kind, *i.e.*, a maple was inoculated with juice from a diseased maple shoot, etc. In not one case could we find that the trouble was either contagious or infectious in character. The results of these inoculations are given in Table I., and from these results it is evident that the disease cannot be communicated from one plant to another.

[1] A. F. Woods, U. S. Dept. Agr., Bur. Plant Ind., Bul. No. 18.

TABLE I.

SERIES A. — *Showing Results of Inoculation of Healthy Young Growth with Tissues from Malformed Plants.*

PLANT.	Number inoculated.	Number diseased.	Remarks.
Maple (*Acer rubrum*),	10	None.	The terminal bud died in two cases, but this was due to mechanical injury.
Chestnut (*Castanea dentata*),	10	None.	
Oak (*Quercus alba*),	8	None.	
Poplar (*Populus tremuloides*),	10	None.	The terminal bud died in three cases, but this was due to mechanical injury.

SERIES B. — *Filtered Juice used for Inoculation.*

PLANT.	Number inoculated.	Number diseased.	Remarks.
Maple (*Acer rubrum*),	14	None.	
Chestnut (*Castanea dentata*, Borkh.),	11	None.	
Oak (*Quercus alba*),	10	None.	Inoculated twice two weeks apart with juice.
Poplar (*Populus tremuloides*),	10	None.	
Ash (*Fraxinus Americana*),	5	None.	

The appearance of the leaves of "mosaic" plants is usually different from that of diseased shoots in the case under discussion. In mosaic these are flattened areas of cells which are lighter in color than the normal areas, and which are also smaller in size, growing more slowly than the normal cells, this causing a general unevenness or distortion of the leaf.

On the other hand, in the trouble under discussion, where abnormality occurs, the tissue of the leaf itself is not so much distorted as the vessels and veins. These are usually curved more or less, and thus distort the leaf. The leaf, also, is always of a healthy dark-green color, and shows no division of color into light and dark areas. Plate II. (Figs. 4 and 5) shows a typical mosaic leaf and some from affected sprout growth.

The cause of mosaic is not exactly known, but it has been produced repeatedly by severe pruning in the case of tomatoes,

tobacco and other allied plants. It occurs on tobacco, also, without pruning in the field, due to some functional disarrangement in all probability; but in the case of tomato we have not been able to find a case in which the disease occurred on a plant which was allowed to grow normally, that is, without pruning. Plants in the field are also not so susceptible to it, and it is rather difficult to conceive just why it is that under similar conditions, but with different plants, we sometimes get the characteristic mosaic disease and sometimes only a condition such as the one under discussion.

Relation of Root Area to Intensity of Disease.

In the course of our experiments it was observed that in the same locality, with the same kinds of trees, there was a marked difference in the intensity or severity of the malformation. It was thought that the size of the original tree and its corresponding root area might bear some relation to the severity of the disease. Rough estimates were made of several root systems from which first-year sprouts were growing which were diseased, and in general it was found that the larger the root area the more distortion of the leaves. This seemed to be the general rule, but from the limited number of observations we were able to make it would be unwise to make a positive statement as to the absolute truth of this observation.

When young trees had been cut down or killed by burning, there was not such severe distortion, but more of a tendency to produce abnormally large leaves. As a result of our observations it may be stated that there is a relationship existing between the amount of active root surface and the severity of the trouble along the lines we have pointed out.

It has been stated elsewhere in this article that the severity of the disease diminishes from year to year as the plant grows older, and it would be natural to expect such a recovery for two reasons: first, the shoot is larger the second year than the first, thus having more leaf surface to effect transpiration, respiration, carbon assimilation, etc.; and secondly, some part of the root system, owing to lack of food (available), which the first year's leaves have been unable to supply, has died from general

weakening; thus the second year, and so on from year to year, we have a general attempt to balance up the root system and the leaf system. It is believed that this view is in accordance with the truth, although no specific work has been done here to prove it other than general observations.

Chemical Tests of Abnormal Leaves.

In view of the fact that physiological diseases in general are principally caused by derangement of the function of some organ of a plant, as a result of poor nutrition (lack or excess of some necessary plant food), it was thought that it would be well to obtain, in a general way, an idea as to the presence and absence of certain substances in the leaves of diseased plants. Owing to pressure of other work it was necessary to use dried specimens for examination. The specimens, however, were not over one or two months old when the examinations were made, therefore no great change of constituents could have taken place, with the exception of loss of water, and this was not of any importance. A complete analysis was not made of the leaves, but comparative tests were made, comparing the substance in healthy leaves with the same amount of diseased leaves. The substances tested for were principally nitrates, enzymes and starch.

As Woods [1] in his bulletin on mosaic disease advances the theory that it is caused by an excessive amount and increased activity of oxidizing enzymes, such as oxidase and peroxidase, equal amounts of leaves from healthy and diseased leaves were tested to see if there was any increase or decrease in the relative amounts present. It was found that in general there was usually present in diseased leaves a slightly larger amount than in the healthy leaves, but it was not necessarily so, as in five cases out of eighteen there was less present; but this may possibly have been due to individual variation in the leaf itself, as the method of taking equal weights of leaves for examination has some drawbacks, but no better method has as yet suggested itself.

It was found that catalase, another enzyme which was discov-

[1] *Loc. cit.*

ered in connection with tobacco by Loew,[1] was present in both healthy and diseased leaves in comparatively small amounts, but that there was practically no difference in the amounts present. Twenty samples of healthy and diseased leaves were tested, and below will be found a table containing the averages of these tests. The comparative amounts present were represented by the oxygen developed from a standard solution of hydrogen peroxide, which contained 3 per cent. H_2O_2.

TABLE II. — *Amount of Oxygen developed from Healthy and Abnormal Leaves.*

[Averages of twenty samples.]

	Number of Samples.	Amount of Oxygen developed.	Time.
Abnormal, ...	20	118.5	30 min.
Healthy, ...	20	114.0	30 min.

The samples were shaken during the test, as this has been found to increase the amount of oxygen developed.

Fifteen grams of leaves were used in each case.

Individual variations were found in most cases between leaves of different kinds, but not sufficient to warrant distinctive mention.

Thus, in respect to the amount of catalase present we find that there is a difference between this disease and mosaic, for in the case of mosaic disease there is less catalase present in the diseased leaves than in the healthy ones.[2]

Colorimetric tests of healthy and diseased leaves were made to determine the relative amounts of nitrates present, and it was found that in the case of diseased leaves a deeper color was obtained than in the case of healthy specimens. The test for nitrates used was the well-known diphenylamine reaction. Only approximate results were obtained, but sufficient to show that nitrates were more abundant in diseased leaves than in normal specimens. This tends to confirm the idea that this disease is more a form of malnutrition or overfeeding than a specific trouble, such as "mosaic."

Aside from the direct work on the disease it was observed in some few cases that diseased leaves were more liable to the

[1] U. S. Dept. Agr., Report No. 68.

[2] Mass. Agr. Exp. Sta. report, 1908.

attacks of leaf-sucking insects, such as aphis, etc., as in a few instances specimens of diseased shoots were obtained which showed the effects of these insects, and some aphides were found also. No insects were observed, however, on healthy shoots, or to so great an extent on shoots which had only a slight indication of the disease in question. It appears from our observations that the disease renders the shoot more liable to the attacks of insects on account of its weakened condition, in some respects it being far more normal; also, the attacks of insects intensify the disease by taking from the leaf a large amount of proteids and sugars. The effects of insects have been noted by various authorities, among which may be mentioned Woods [1] and Suzuki.[2] More specific and interesting facts on this point might be brought out by further observations and detailed study in conjunction with entomologists, but this is without the scope of the present paper. It is, however, true that insects seem to prefer a diseased leaf to a healthy one under these conditions.

More purely chemical work would undoubtedly be of great interest in connection with this interesting disease, and no doubt will find a place in a future report, but it is thought that enough has been done with the disease to bring out several new points in regard to it.

Conclusions.

(1) The abnormal condition of leaves, shown by severe distortion and increase in number, and also sometimes in size, may be classed under the malnutrition diseases, due to functional derangement, as no fungi or bacteria have been found associated with it. It must therefore be due to internal conditions, such as an abnormal metabolism.

(2) It is allied to those pathological conditions which may be brought about by excessive use of nitrates or overfeeding.

(3) It is not allied to mosaic disease, which it somewhat resembles, as this is capable of transmission from one plant to another, and in no case have we been able to bring this result about by inoculation with tissue of malformed leaves.

(4) From our observations it is not of a permanent character,

[1] U. S. Dept. Agr., Bur. Plant Ind., Bul. No. 18.
[2] Gen. Bul. Col. Agr., Tokyo, Vol. IV., No. 4.

as the shoot will outgrow it in from three to five years, and does not seem to suffer any serious ill effects from the trouble.

(5) It is caused by a sudden disruption of the metabolic processes of the tree, all leaf activity being suspended; and there being no normal relationship between root metabolism and leaf metabolism, the new shoot is unable to properly bring into available form the food supplied for the nourishment of the tree. In other words, there is an attempt on the part of the leaves to correlate their functions with a root area many times larger, and consequently a pathological condition is set up within the tissue, due, as has before been said, to imperfect metabolism.

PEACH AND PLUM TROUBLES.

BY RAYMOND DEAN WHITMARSH, B.S.

Many diseases of the plum and peach have been known and described for years. Standing probably first among the most serious of the fungi are "brown or fruit rot," or *Monilia* (*Sclerotinia fructigena* (Pers.) Schroet.), and scab (*Cladosporium carpophyllum,* Thümen). These fungous troubles have been very noticeable in the peach and plum orchards at the college during the past year or two.

The writer began investigations early in January, 1909, mainly to determine the cause of so much gum flow on the peach, almost every tree being affected to a greater or less extent. In connection with this study nearly every phase of the above diseases as they are described by various writers was noted, and a brief résumé of their characteristics and methods of treatment is given here, with observations on "gummosis" of the peach.

This paper has been prepared under the supervision of Dr. G. E. Stone of the Massachusetts Agricultural College, and to him I wish to express my heartiest thanks for his many suggestions, criticism of manuscript and verification of observations.

Brown Rot or Fruit Rot, Monilia (*Sclerotinia fructigena* (Pers.) Schroet.).

Distribution and Host Plants. — This disease is reported by Saccardo as being found in Germany, France, Austria, Italy, Belgium, Great Britain and the United States, where it is known as *Monilia fructigena,* one of the "imperfect fungi." Tubeuf and Smith speak of the disease as being very common in the United States and Great Britain. It was first described in the United States by Dr. C. H. Peck in 1881; since that time

a great many investigators have been at work on it. Finally, Prof. J. B. S. Norton in 1902 succeeded in giving us its life history in full, having found the ascospore stage. Within the United States, at least, the greatest damage is caused to the stone fruits.

Symptoms (*on Fruit*). — The first indications of the disease on the fruit are brown spots of a leathery appearance, which enlarge rapidly, and after the mycelium has become mature, the conidiophores break through the epidermis and give to the spots a downy, dirty, grayish-brown color, due to the great quantity of conidia produced by the fungus. The fruit then shrinks and withers to a thin, tough pellicle. In this "mummied" condition it hangs on the trees over winter or falls to the ground, where the fungus remains dormant until the right conditions of moisture and temperature cause it to become active and attack its host the following spring. The dormant or sclerotium form of this fungus occurs where the "mummied" fruit has laid on the ground over winter, covered by a thin layer of soil. These sclerotia give rise to apothecia, which are funnel-shaped, resembling small toadstools. The asci line, the cup-shaped portion of the apothecia and each ascus, contains eight ascospores. So far as I know this has not been found by any of the Massachusetts Experiment Station staff. The fungus will attack the fruit at different stages of its growth, but it makes the greatest headway on fruit that is almost mature. If the fruit has been attacked by the curculio, or injured in any way, the fungus readily takes advantage of the injury to get in its deadly work. It might be said, however, that although it attacks the fruit most readily where it has been injured, it will also attack the perfect fruit should the humidity and the temperature of the atmosphere be right. In the case of plums the fungus may have been working for some time within the tissue without being outwardly noticeable. This fact has put many shippers to great disadvantage and caused them much loss.

On Flowers. — The fungus usually first attacks the flowers just after the petals fall, but it has been known to attack them previous to that time. The first indication that the fungus is present is a slight brown discoloration on some part of the

flowers. This rapidly spreads until it affects the whole flower, and frequently extends into the pedicles. These diseased flowers often remain on the tree several weeks, until a heavy rain or damp weather comes, when they begin to fall, and as they are very sticky, owing to their decaying condition, they adhere very effectively to leaves and fruit, and serve as a new place of infection. They may remain in these new locations for some time before they are washed to the ground. When the fungus from the flower penetrates the pedicle, we have what is commonly called "twig blight."

On the Twigs. — One form in which the fungus attacks the twigs is commonly known as twig blight, and it is apparently a result of the early attacks on the blossoms. I have noticed it attacking both the peach and plum, but more often the former. The fungus penetrates the pedicle and into the tissues of the twig, causing a flow of gum. This fungus often works around the entire stem, cutting off all source of nourishment from the distal portion of the twig, causing it to die. The gummy portions and girdling resemble quite closely the symptoms of another disease, known as canker. In summer and early fall, as well as in spring, we often find this blighting of twigs, the source of infection being the fungus from the decaying fruit. This bores through the pedicle and then ramifies through the stem, often girdling it, as in the case of the blight, where the source of infection was the flowers. The injury in both cases nearly always is confined to a point near the attachment of the fruit or flowers. When the girdling is complete the leaves beyond the point of attack dry up and die.

Another form in which I have noticed it might be called the "brown spotting of twigs." This phase of the disease has been described by Dr. G. E. Stone of the Massachusetts Agricultural College. The spotting occurs on the new shoots, and was not noticed except in the case of the peach. These spots may be single, or several may come together, forming a more or less irregular mass. In these spots we find *Monilia,* which presents similar characteristics to the one found on the fruit. The principal distinction between this and the common *Monilia* of the fruit consists in the smaller spores of the former. Numerous

cultures and comparisons made of the two types of *Monilia* — that on the fruit and on the stem, made by Dr. Stone — show that the spores of the one on the twig are always smaller when grown in any media than those of that on the fruit, and the two species react quite differently chemically when grown in solutions on different media.[1]

On the Leaves. — In wet weather, especially, one often notices spots on the leaves. These are found on both the upper and lower surfaces, but are generally most conspicuous on the upper. During wet, warm weather, if one examines these spots carefully he will find here and there small grayish masses of powder, which are in reality the conidia of the "brown rot" fungus.

Spores. — The spores, more or less oval shaped, are one celled, and their contents are quite noticeably granular. These spores germinate readily in water, producing a mycelium whose contents are granular, as in the case of the spores. The mycelium is broken up here and there by cross walls. The spores are produced in chains by a sort of budding, the last one of the chain being the newest one. When grown on culture media (prune agar) these spores form much longer chains than on the fruits out of doors.

Means of Spore Dispersal. — The influencing factors in the spreading of this fungous disease are wind, rain, insects (especially plum curculio), etc. Many minor ways in which the spores are disseminated might be enumerated, but the three above-named methods are probably by far the most influencing.

Methods of Control. — I would suggest the following ways in which to lessen the attacks of this disease. Destroy all "mummied" fruit which hangs on the trees or has fallen to the ground. Cut off and burn all twigs that are infected with the fungus mycelium. Keep the trees pruned, so that there will be a free circulation of air and plenty of light, because a tree which is crowded with cross limbs and has in consequence too much foliage acts as a convenient forcing house for "brown

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[1] Dr. Stone has observed this species on the twig for many years in Massachusetts, the twig sometimes being very badly spotted. *Monilia* is also sometimes associated with *Cladosporium*, but the *Monilia* by far predominates. Where lime and sulphur has been used as a spring spray these spots have been entirely absent, with a much better annual growth of the twig as a result. (See Nineteenth Annual Report, Massachusetts Agricultural Experiment Station, p. 166.)

rot." Thin the fruits so that they do not at least come in contact with one another. By using the above precautions and applying the following spray mixtures for "brown rot," "scab" and "plum curculio" I believe that the fungus can be almost entirely controlled. For the Elberta, Belle, Reeves, and other varieties of peaches of about the same ripening season, the following is advised: (1) about the time the calyces of shucks are shedding, spray with arsenate of lead at the rate of 2 pounds to 50 gallons of water. In order to reduce the caustic properties of the poison, add milk of lime made from slaking 2 pounds of stone lime. The date of this treatment is too early for scab, and ordinarily no serious outbreaks of brown rot occur so early, so that the lime sulphur may be omitted with reasonable safety; but during warm, rainy springs, especially in the south, the lime sulphur will doubtless be necessary in this application. (2) Two or three weeks later, or about one month after the petals drop, spray with self-boiled lime sulphur; 8 pounds of lime, 8 pounds of sulphur and 2 pounds of arsenate of lead to each 50 gallons of water. (3) About a month before the fruit ripens, spray with the self-boiled lime sulphur, omitting the poison.

For earlier maturing varieties, such as Waddell, Carmen and Hiley, the first two treatments outlined above would probably be sufficient ordinarily, but in very wet seasons varieties susceptible to rot would doubtless require three treatments. Late varieties, such as Smock and Salway, having a longer season, would not be thoroughly protected by three applications. In view of the results obtained on midseason varieties it seems likely that three treatments will ordinarily be sufficient for the late varieties.

Black Spot or Scab (*Cladosporium carpophyllum,* Thüm.).

History and Distribution. — This fungus was first noticed in 1876 by Von Thümen of Austria, who was at that time botanist to the Austrian Experiment Station. In the year following, 1877, he described the fungus, giving it the above name. Since that time it has been met with quite commonly in this country. In Saccardo's "Sylloge Fungorum" we find a copy of Von

Thümen's description, which mentions only that it was found in the locality of Klosternenburg, where the Austrian Experiment Station was located.

On the Fruit. — Small, round, blackish spots on the skin of the fruit are the first indications of the disease. These spots usually appear when the fruit is about two-thirds grown, most frequently on the upper side of the fruit, and if the spots are very numerous they will, as they grow, coalesce and form a large, irregular, diseased area. When the fruit is thus attacked it becomes one-sided, due to the fact that a corky layer of cells is formed by the fruit under the diseased area as a protective layer. This corky layer is incapable of further growth, and hence we get, as a result, the ill-formed fruit. The corky layers are often ruptured, leaving deep cracks, which furnish an ideal place for the growth of the spores of *Monilia,* which are always ready to take advantage of such injuries. Hence we often find both troubles on the same specimen. This disease attacks the fruit much in the same way as the scab of apple and pear. Its attacks are generally most noticeable on the late varieties of fruits, and it thrives most luxuriantly during damp weather.

On the Leaves. — This fungus causes a shot hole appearance of the leaves. The first indications one has of the disease upon the leaves are scattering brown spots. These spots, as a rule, spread over the leaf, and as the fungus matures the tissues dry up and the diseased portion falls out, leaving a circular opening. This fungus seems to prefer the part of the leaf between the veins. The spores of the fungus attacking the leaf agree with those growing on the fruit, with the possible exception that they are somewhat smaller, but no doubt this slight variation is due to the environment rather than being a specific character.

On the Twigs. — Sturgis gives an account of this fungus attacking the peach twigs. He states that the twigs are marked more or less abundantly with circular spots, somewhat resembling in appearance the "birds' eye rot" of grapes (*Spaceloma ampelinum,* DeBary). Frequently the spots join together and cover the twig so thoroughly as to destroy the pinkish-brown color of the bark. Although not having seen this phase of the

disease, it apparently resembles in outward appearance very much the spotting that I described as due to the brown rot fungus.[1]

Peach Leaf Curl (*Exoascus deformans* (Berk.) Fuckel).

This disease is found commonly in Massachusetts, and, as a matter of fact, more inquiries are sent to the station in regard to this trouble than any other peach disease. It is found in almost all parts of the world where the peach is grown to any extent, and has been seen by the writer in great quantities in the large orchards along the shores of Lake Erie.

It attacks the leaf buds just as they begin to open in the spring, also the tender shoots, flowers and young fruit, but is not so noticeable as on the leaves. The leaves become very much swollen, wrinkled and curled, and a little later take on the appearance of a moldy gray covering. In the earlier stages of the disease the leaves often show red or pinkish blotches, but they turn a brownish color as they grow older and fall to the ground. Cold and damp, or rainy, weather in the spring greatly favors this disease, and in fact determines the degree of severity of the attack. It often defoliates the trees to such an extent that they are not able to lay up sufficient material for their needs, or ripen the wood properly, so that when winter comes the trees are often found to be much weakened. In some cases the disease has been so severe that the trees were not able to endure the cold of winter, and consequently were winter killed.

It was previously thought that infection took place only by perennial mycelia, but this theory has gradually been discarded. Infection may take place by perennial mycelia, but most writers and observers now agree that infection is due almost entirely to the spores, which live over winter on the bark of trees and in other places.

The Elberta peach is one of the most susceptible varieties to the attacks of this fungus, but all varieties seem to be more or

[1] For other points of interest in regard to the fungus not given in this paper see Arthur's and Chester's writings.

less subject to the disease. Trees injured by other agencies, and consequently weakened, seem to be more susceptible to attack than healthy, vigorous trees.

It will be readily seen that it is probably useless to spray the trees after the leaves become infected, but since the spores live over winter on the bark, the trees should be sprayed in the spring, while the spores are still dormant.

It is generally accepted by all the largest and best growers that the lime sulphur wash, used for the control of San José scale, is by far the best remedy for this trouble, although some prefer Bordeaux and others copper sulphate solution, where the scale is not present. Since there is nearly always danger from scale infestation, however, it seems wiser to use the lime and sulphur, which is undoubtedly of great fungicidal value, as well as one of the best remedies for the scale.

The spray should be applied to the trees from one to two weeks before the buds open, if possible on a quiet day when the atmosphere is free from moisture.

If the above directions are followed, this treatment should suffice for the leaf curl and the San José scale. For this spray mixture use 10 pounds of good fresh stone lime and 15 pounds of sulphur to each 50 gallons of water. Make up the above spray solution as recommended by Quaintance.

Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot, add all the lime and at once add all the sulphur, which previously should have been made into a thick paste with water. After the lime has slaked, about another third of the water should be added, preferably hot, and the cooking should be continued for one hour, when the final dilution may be made, using either hot or cold water, as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by steam, no stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray pump or tank. The wash may be cooked in large kettles, or, preferably, by steam in barrels or tanks.

Plum Pockets (*Exoascus Pruni,* Fuckel).

The organism causing the disease known as "plum pockets" is closely related to that causing peach leaf curl, although not occurring on the peach. It was previously thought that the source of infection was only through the hibernating mycelium in the twigs and branches, but from what can be learned in regard to this more investigation seems to be needed on this point. A short time after the young fruit forms, it becomes yellowish, much swollen and stoneless.

These hollow, dropsical-like plums are often streaked with red at first, but after a time they take on a moldy, grayish appearance, similar to the peach leaf curl, and soon fall to the ground. This moldy covering is composed of sacs (asci) which contain the spores.

The attacks of this parasite are generally local, possibly only one tree in a large orchard being affected, and the treatment given for peach leaf curl would probably suffice here.

Black Knot (*Plowrightia morbosa* (Schw.) Sacc.).

One often notices in small family orchards containing a variety of trees, where little care is given them, that some of the plum trees show signs of a disease known as black knot. The knots often extend entirely around the limbs, and as a consequence the more distal parts of the limbs receive but little nourishment, and finally die.

Black knot, if given no treatment, usually destroys the value of the tree within a year or two, even if it does not kill the tree in that time. Almost all varieties of plums are subject to this disease. The first noticeable indication of the disease in the spring is the enlargement of limbs and branches affected. The bark then breaks open, and this new surface soon becomes covered with a moldy, green-like substance which contains the spores. This is followed by black knots containing spores which become mature before the next spring. The spores evidently obtain a foothold on their host through cracks or injuries caused by various agencies. It is therefore essential in the care

of an orchard that one should be careful not to bruise or injure the trees.

The wind is probably the greatest agent for conveying the spores from tree to tree. Remedial measures consist in pruning off the knots and burning, and it has been advised that they be cut out when young, and the exposed area coated with paint. Observations and experiments have shown that early spring spraying materially lessens the infection.

Plum Leaf Spot or Shot Hole (*Cylindrosporium Padi*, Karst).

This disease causes spots on the leaves somewhat circular in outline, which often become joined. These affected parts usually have a reddish outline, and finally the diseased tissue turns dark brown and falls out. The leaves turn a yellowish color and often begin to fall in July, but the most severe defoliation usually occurs in August and early in September. The great loss from this disease is caused by defoliation before the tree stores up sufficient starch and ripens its wood enough to enable it to stand the cold of winter. Continual attacks very much weaken the tree and eventually kill it, but if lime sulphur is used thoroughly, little trouble will be experienced from this disease. This same disease also affects the cherry.

Peach Shot Hole (*Cercospora circumscissa*, Sacc.).

The effects of this disease resemble those caused by *Cylindrosporium* of the plum. The diseased spots fall out, and the small branches are also attacked, often causing a great number of the young shoots to die. Spray with lime sulphur, as for peach leaf curl.

Shot Hole Effect caused by improperly mixed Bordeaux.

When improperly mixed Bordeaux is used for a summer spray, we invariably find the leaves badly riddled with holes, due to the burning of the tissues. One can readily distinguish this type of shot hole from those previously described, for the leaves which come out on the new shoots remain unaffected,

whereas, if the trouble had been due to a fungus, the new leaves would also become affected. Bordeaux is not, therefore, always safe to use on mature foliage, even at reduced strengths, for it has often been known to cause trouble when used at only half strength.

Gummosis of the Peach.

For the past two years there has been an abundance of gum flow in the college peach orchard. This has been found to the greatest extent on the early varieties, and owing to the poor condition of many of the trees it has seemed best to destroy them. The following gum disease which I am about to describe resembles almost identically in most of its life history the gummosis of *Prunus Japonica,* described by Masseé as due to *Cladosporium epiphyllum,* Fr. In this case (gummosis of peach) I believe the species to be *Cladosporium carpophylum,* Thüm. Masseé mentions in his paper a species of *Macrosporium* that is often found in connection with this gum flow, but he is unable to find any genetic connection between the two fungi. Instead of finding a *Macrosporium* fungus in connection with the gummosis of peach, I have, with very few exceptions, found a species of *Alternaria* [1] or *Alternaria* form, which is apparently something new, as the fungus, in addition to the ordinary alternaria spores, bears pycnidia bodies containing many minute hyline spores. These in turn give rise to *Alternaria* spores and more pycnidia. I could not, however, establish any genetic connection between this form of *Alternaria* and the *Cladosporium.*

Probable Cause of Gummosis.

On the trunks and large branches the gum flow is evidently due to borers, frost cracks and sun scald, and a copious flow of gum at any place of injury is generally found. These places serve as a refuge for the spores of *Cladosporium* and *Alternaria,* and we find some form of *Penicillium* inhabiting the same mass. But whatever the original cause of the flow, it is certain that these forms of *Cladosporium* and *Alternaria* take a hand in

[1] The organism which we term *Alternaria* here may possibly be an undeveloped form of some other type, such as *Pleospora,* etc.

stimulating the host to a more abundant flow. The mycelium of these fungi penetrate every portion of the gum, and their fungous threads may be seen even penetrating the host itself.

On the Fruit-bearing Wood.

The gum flow is almost without exception found at the base of the pedicle bearing diseased fruit. These gummy masses may be confined to a small area in the region of the pedicle, or may extend some little distance below and above the pedicle, sometimes becoming so bad as to entirely girdle the branch, thus killing the entire distal portion. When this happens it is best to cut the diseased member off some two or three inches below the gummy area. I believe this gum flow is first caused on these small branches by the brown rot fungus, which is, without an exception, found on the fruit attached to the diseased pedicle. But as soon as this fungus causes the flow of gum the *Cladosporium* and *Alternaria* come in, as in the case of the injuries on the trunks and large branches. After the above fungi, *Cladosporium* and *Alternaria,* get a foothold, it would seem that the brown rot fungus is less noticeable. *Monilia* is often to be found in these gummy masses, but in masses containing *Cladosporium* and *Alternaria* this fungus has been found very sparingly. These masses become soft during the damp spring weather, and are usually washed to the ground by rains.

Appearance of Cladosporium and Alternaria under the Above Environment.

At first the gummy mass is light in color, but after it remains on the tree some time it becomes browned and blackened. On sectioning one of these masses it is found that the darkened area is near the surface, due to the formation of dark, thick-walled cells, while farther in the mycelium becomes gradually lighter in color, until nearly colorless at the center. On inoculating branches of peach trees with the conidial form of *Cladosporium* grown on prune agar it was found that some little time afterwards a greenish growth of *Cladosporium* appeared. After the spores had disappeared there soon appeared small, tear-like drops, which, as the season advanced, grew larger and darker

Showing a Cross-section of a Three-year-old Peach Twig affected with "Gummosis."

in color. On examination in the fall these masses were found to contain mycelium and spores similar to those found in other gummy masses in the orchard. These chains of dark spores produce many thick-walled spores, or micro-sclerotia, as described by Masseé, and these thick-walled spores, or micro-sclerotia, in turn give rise to many small hyline conidia, while another form of the micro-sclerotia gives rise to a mycelium which bears numerous conidia. In the gummy mass one finds present many pycnidia of a brown color, similar in color to the micro-sclerotia, and from their situation, color, etc., one would take them for different stages of the same fungus. However, on isolating these pycnidial bodies, which were filled with myriads of minute hyline spores, and growing them on pure cultures, I was unable to get any connection between the two; but I found that the minute hyline spores without exception gave rise to other pycnidia and *Alternaria* spores; the *Alternaria* spores, growing on the same mycelium as the pycnidia, in turn gave rise to pycnidia and *Alternaria* spores.

Histological Changes Accompanying Gummosis.

The cut facing this page represents a cross-section of a diseased twig of a peach tree, showing two well-developed annular rings and a third partly developed. This twig was probably attacked by the brown rot fungus, together with *Cladosporium* and a form of *Alternaria.*

This section, which is a typical one, shows that the disease did not destroy the cambium ring until the fall of the second year, but the disease may have made its appearance even a year earlier. The noticeable feature in this illustration is that the last layer of wood formed was very much thinner towards the uninjured side of the twig than the injured side, and this ring of wood is not complete near the area where gummosis had set in. There is also a noticeable thickening of the incomplete rings of wood near the point of injury, a fact due probably to the difference in tension occurring in the stem produced by the injury from gummosis. The cambium, at the margin of the diseased area where it has attempted to heal over, is also much

thicker than at the opposite side of the twig, where the tension is different.

Microscopical examinations of sections also showed that considerable healing of the wound caused by gummosis took place. The callus forming as a result of this healing developed ridges along the side of the wound. The cavity of the wound was entirely filled with gum, which contained *Cladosporium* and a form of *Alternaria.*

Suggestions in Regard to the Treatment of Gummosis.

In very bad cases of gummosis it would be best to destroy the tree, since it is of little value and may possibly furnish an ideal place for the development of undesirable organisms. Branches may be cut off a few inches below the affected areas. Since this disease undoubtedly originates from the practice of leaving "mummied" fruit attached to the tree, it is best to remove and destroy them. It is even a question whether "mummied" fruit should be left on the ground. Practically all cases of infection from gummosis have occurred where the "mummied" fruit was left on the tree, and came in contact with the limb or branch.

Care should also be exercised in pruning, and this should be done in winter or early spring. A clean, sloping cut should be made, and large wounds should be covered with paint or coal-tar. This treatment will prevent infection from the wounds.

The practice of good sanitation and systematic spraying of peach trees, together with cultivation and feeding, will undoubtedly hold this disease in check.

Directions for making Summer Spray Mixture.

Essentials.

In making the self-boiled lime sulphur plus arsenate of lead, as recommended for the summer sprayings, the first essentials are to have good stone lime, a perfect mixture of the ingredients, and two men to attend to the mixing. After being mixed it is necessary that the mixture be kept well agitated while in the tank, for if not it will settle, no matter how well made. To

accomplish this it is suggested that those using a power outfit employ an agitator of the propellor type, as most others will allow a little settling; and where this occurs an even mixture of the spraying materials is not obtained.

Directions.

The following method has been found to work out satisfactorily in making 250-gallon quantities. First, weigh out 40 pounds each of good stone lime and flour of sulphur. Take the above quantity of lime and place in the bottom of a barrel (one holding 50 gallons is a convenient size to use when not making over 300 gallons at a time); then pour on water slowly and evenly. A good way to do this is to use a fine spray from a nozzle. As soon as the lime begins to slake have the sulphur sifted over the lime, adding just enough water while doing this to keep the lime from burning. By the time the sulphur is added the lime has become very active, and requires one person's attention to stir the mixture while another adds the water just fast enough to keep the mixture from burning. Water should be added cautiously to obtain the best results in slaking.

If the above directions are followed there will first be a thick, pasty substance which gradually becomes thinner as more water is added. The lime ought to keep the mixture well heated for several minutes, but as soon as it becomes well slaked water should be added. If allowed to cook too long the sulphur will go into solution and combine with the lime to form sulphides, and this form is harmful to the foliage. Weigh out 10 pounds of arsenate of lead, add water, and stir until thoroughly mixed; then strain through a sieve (20 to 30 mesh to an inch is satisfactory) either into the spray tank or barrel containing the lime-sulphur mixture. On the addition of the arsenate of lead to the lime sulphur, a dark-colored mixture is obtained. If the mixture has been properly made there will be very few settlings, and very little, if any, sulphur floating on the surface. The ingredients of this mixture ought not to settle for nearly half an hour. The above mixture should be strained into the spray tank and the tank filled with water. The solution is then ready to be sprayed on the trees.

Concentrated Lime-sulphur Solution.

The inconvenience experienced in preparing the lime-sulphur wash by cooking with steam or in open kettles at home has been one of the principal objections to this spray. Certain manufacturers have therefore put on the market concentrated solutions of lime-sulphur wash which have only to be diluted with water for use. These commercial washes have proved to be about as effective in controlling the scale as the well-cooked lime-sulphur wash, and, although somewhat more expensive, have been adopted by many commercial orchardists in preference to the home-prepared spray. They are especially useful for the smaller orchardist, whose interests do not warrant the construction of a cooking plant. In other ways, too, they possess advantages; for instance, those using the commercial washes may always have on hand a stock solution, so that the spray may be quickly prepared and advantage taken of favorable weather conditions. These preparations should usually be used at the rate of 1 gallon to 10 gallons of water.

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CLIMATIC ADAPTATIONS OF APPLE VARIETIES.

BY J. K. SHAW.

I. INTRODUCTION.

The conditions of soil, climate and culture under which our many varieties of fruit succeed are little understood. Most of the publications dealing with varieties concern themselves with histories and technical descriptions, and but very little with the conditions under which the planting of this or that variety is to be recommended. As a result of this lack of information a given variety is planted under widely varying conditions, under some of which it does well and under others it does poorly.

At the present time fruit growing, more especially the growing of apples, is entering a new era. The increased demand resulting from the lessened production during the past decade; improved methods of culture, especially a better understanding of the combating of insects and diseases, and better business methods have stirred up growers all over the apple regions to a renewed interest in the business. This movement has had its origin in the Pacific coast and intermountain regions, but will soon, if it has not already, become general over a large portion of North America.

This movement will result in more or less change in the relative importance of commercial varieties, some becoming less esteemed and others gaining in favor. The consumer will come to prefer varieties of better quality and those better suited to various purposes. The same is true within a variety, where specimens grown to more perfect development will receive preference.

To attain the highest degree of success it will be more necessary than in the past for each grower to choose those varieties which he can grow, under his conditions of soil and climate, to

their highest perfection. A mistaken choice will be a serious thing, and one that will require valuable time and much expense to correct.

The present paper is the result of a study, carried on for the past four years, of the effect of varying climatic conditions on varieties, and an attempt is here made to lay down certain principles as to the climatic adaptations of varieties. Questions of soil and culture are given only incidental consideration. For the former there has not been sufficient opportunity, and a consideration of the latter would lead into the whole field of orchard management. Many samples of different varieties, grown under widely varying conditions, have been examined pomologically, and some of them chemically, and a study made of the pomological and meteorological literature available.

This paper does not make specific recommendations of varieties for any section of the country or for the country in general. That is more or less a local problem into which enter questions not considered here. Among them are those of soil, market demands, methods of culture to be followed, the individual preferences of the grower and many others. If the conclusions of this paper are sound, they should aid in such choice, for many varieties that might otherwise be considered are excluded as not being suited to the climatic conditions of the locality under consideration, while from those that are adapted climatically, the ones best suited to soil and other conditions may be singled out.

The subject under consideration is a large one. To understand at all fully the relations of apple variation to climate will require prolonged study and experiment. This paper is, in a large degree, introductory, and may contain errors and omissions which should be corrected. The writer will greatly appreciate any suggestions as to corrections or additions that should be made.

The work has been done as Adams fund research, and at the same time in partial fulfillment of the requirements for the degree of Doctor of Philosophy from the Massachusetts Agricultural College. It has been done under the direction of Prof. F. C. Sears, to whom the thanks of the writer are extended for

advice and criticism, and to Prof. F. A. Waugh as well, who has given many helpful suggestions. The chemical work has been under the direction of Dr. Charles Wellington, and assistance in the analytical work has been rendered by Mr. E. L. Winn and Mr. B. Ostrolenk of the senior class in the college. Many experiment station horticulturists and fruit growers in many sections of the country have aided by giving information and by furnishing samples of apples. It is impossible to name them all here, but their many favors are here acknowledged and hearty appreciation extended.

II. THE CAUSES OF VARIETAL VARIATION.

The causes of the great differences in apple varieties may be grouped under three heads: those arising from (1) cultural conditions, (2) differences in soil types, (3) differences in climate.

Cultural Variations.

The methods pursued in the growing and in the care of the trees have great influence on the character of the fruit. It is affected in every way, in size, form, color, keeping quality, shipping quality and dessert quality. These variations have been given only incidental investigation of such phases as relate directly to the climatic differences that have been the special object of study. A few of these may, however, be given passing attention at this point.

Every orchardist growing any number of trees is aware that there are great differences in the individuality of the trees, even when grown in the same orchard and under apparently identical conditions of climate and soil. One tree may be very productive and its neighbor only moderately so. The apples may differ in many of their characters. Further along in this paper some data are presented bearing on this question (see page 194). These individual differences have been ascribed to various causes, the principal ones of which are, perhaps, those of bud variations or varietal "strains," and that of the influence of the stock.

The method of handling the soil has great influence on the fruit, especially whether the orchard is in sod or is cultivated.

This has been shown in various bulletins from different experiment stations. The Baldwin seems especially influenced by conditions of orchard culture, and other varieties more or less so.

Certain experiments at this station [1] have shown marked effects from the use of different fertilizers. This question has been little investigated, but no doubt great variation in fruit may be produced by the fertilizer used on the land. Differences in pruning also have their effects. A tree kept with an open top will admit an abundance of sunshine, resulting in a higher colored fruit; in many other ways the effect of pruning may be shown in the character of the fruit.

Many fruit growers have discovered, to their grief, that Bordeaux mixture has a decided effect on many varieties, by producing russeting. On the other hand, the lime-sulphur preparation has frequently been found to render the appearance of the fruit better than when not sprayed at all.

Soil Variation.

It has been shown that the nature of the soil has great effect on the character of the fruit. Red apples are likely to be higher colored on sandy soils than on clayey soils. Not enough is known regarding this question to make any very definite generalizations on the subject. H. J. Wilder has determined the soil adaptations of various varieties, and shown that different varieties have decided preferences as to soils.[2] The question of the adaptation of varieties to soils is much complicated by the question of stocks already alluded to. No doubt varieties have soil preferences which are general to the variety, and not seriously modified by differences in stock. Nevertheless, the writer is satisfied that much greater uniformity would be found in the adaptation of varieties to soils were they grown on their own roots.

Climatic Variation.

In a broad way, the limits of apple growing are governed by climatic conditions. The apple is a fruit of a temperate climate, and does not flourish in the far north nor in the warmer

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[1] Report, Massachusetts Experiment Station, 22, Part II., p. 10.

[2] Proceedings American Pomological Society, 31, p. 138 (1909).

sections of the temperate zones. The apple adapts itself under cultivation to a considerable range of rainfall, and in districts of deficient precipitation irrigation is practiced. Therefore, the question of rainfall has comparatively little weight in the general cultivation of the apple. Sunshine has considerable effect, but it is not a limiting factor anywhere in the apple belt. The great climatic factor which limits the distribution of apples in general, and of the different varieties in particular, is temperature.

Over the greater part of the North American continent the northern limit of successful apple growing is fixed by the minimum winter temperature. Different varieties of the common apple vary greatly in their ability to withstand minimum winter temperatures, and the condition of the tree, particularly as regards moisture content at the time minimum temperatures occur, has great influence in determining whether the tree survives. Very few, if any, varieties will withstand a temperature much below —40° F. without being killed back more or less. In many cases a considerably less severe temperature is fatal to even the hardiest varieties. With the possible exception of the extreme northern Pacific coast, under conditions of a maritime climate, there is nowhere in North America a region where certain varieties will not produce fruit in summer, provided they can withstand the cold of winter. In other words, the summers are warm enough to mature fruit of short-season varieties, provided the winters do not kill the tree before it has reached the bearing age.

The apple does not succeed in the southern portions of North America, although fruit may be produced in every State of the Union, and probably in portions of Mexico. The difficulty in the way of the southern extension of apple growing seems to be largely the heat during the summer. The trees fail to grow during hot periods in the growing season, and fail to set, or at least to mature fruit. The latter is especially true of winter sorts, and many varieties grown in the south are short-season ones, which are able to mature fruit before the hot periods of July and August arrive.

The Mean Summer Temperature.

For this work we have used as a measure of the summer heat an average monthly mean for the growing season. This has been taken as comprising the months of March to September inclusive. The monthly means for these seven months, as given in publications of the United States Weather Bureau and Canadian Meteorological Service, are averaged. This gives, for points within the apple-growing regions of North America, temperatures varying from about 52° to about 70° or 72°. Summer means have been computed for a great number of stations, and from these the isotherms given in Fig. 16 are drawn. This map is intended principally for study in connection with the matter given later in this paper, but it may be proper to explain it at this point, and to discuss the variations in the summer mean that occur and the causes thereof. In common with other questions of temperature, the summer mean for a given section is determined by a number of considerations. Among these are the following: (1) latitude, (2) elevation, (3) site and aspect, (4) soil, (5) culture, (6) prevailing winds, (7) sunshine.

The first two require no explanation. Temperatures vary inversely with the latitude and altitude, but, owing to the influence of the other features mentioned, no ratio can be laid down that is of any value.

With regard to slope, little need be said. The summer mean on a north slope may be several degrees lower than that of a corresponding southerly slope, though we have been unable to find any data showing the amount of difference. Slope must be considered in estimating the probable temperature of an orchard site.

Soils containing a large proportion of sand will not only be warmer than clayey soils, but will also influence the air temperature in the orchard to a considerable degree.

Hedrick found that the soil in a tilled orchard was from 1.1° to 2.3° warmer than a corresponding plat in sod.[1] This must have an influence on the air temperature in the orchard.

Prevailing winds influence the summer mean. These are de-

[1] Bulletin 314, New York Experiment Station.

termined by mountain ranges and other topographic features, by the temperatures of bodies of water over which the air may have passed, and perhaps by other considerations.

The prevalence of a large proportion of sunshine will operate to raise the temperature in the orchard. The effect on the protoplasm of the tree will, owing to the heat absorptive powers of the dark colored bark, be even greater. This has been shown by Whitten. He also found that in peaches the color of the bark modifies in a marked manner the thermal effect of the sun.[1] The temperatures on which this work is based were presumably all taken in the regulation shelters of the Weather Bureau, where this effect would be less than in the orchard. The probable amount of sunshine should be taken into consideration in estimating the summer mean of an orchard.

III. THE DEVELOPMENT OF THE APPLE.

For convenience in discussion, the life history of the apple (fruit) may be somewhat arbitrarily divided into four periods: (1) that of growth, which extends from the blossom to the attainment of full size; (2) that of ripening, which covers the period from the termination of the first until the apple is picked from the tree; (3) that of "after ripening," extending from picking until the apple is in perfect eating condition; and (4) that of decay, covering the subsequent deterioration and breaking down of the fruit. Various fungous diseases may enter in during these periods and terminate the life of the apple at any time. These are not considered in this discussion. The second and third periods are scarcely differentiated in summer apples, these being ordinarily fit for immediate consumption on picking. In winter apples, on the other hand, there is a distinct period of ripening following the picking of the fruit.

Inasmuch as the discussion of these periods of growth will be largely from a chemical standpoint, it may be well to consider briefly the chemical composition of apples before discussing their development.

Apples vary widely in chemical composition, according to variety, stage of development and conditions of growth. They

[1] Report American Pomological Society, 26, p. 47 (1900).

contain ordinarily from 80 to 88 per cent. of water, most winter varieties when maturing averaging perhaps about 84 per cent., the remainder of the fruit comprising the total solids. The solids consist of the following substances: first, starch, of which there may be 3 or 4 per cent., in growing apples; second, sugars, of which there may be from 5 to 12 per cent., averaging perhaps 8 or 10 per cent. The total sugars are made up of at least three distinct compounds: sucrose, of which we may find from none to 6 per cent.; and a mixture of dextrose and levulose, of which there may be from 5 to 10 per cent. These two latter sugars are separated in the laboratory with some difficulty, and comparatively few figures are available to show their relative proportions, but it is evident that the levulose in apples is in excess of the dextrose, a condition not usually found in plant substances where these two sugars occur together. Of organic acid we may find from .12 to 1.50 per cent., presumably as some form of malic acid.

The foregoing solids are all soluble in water. The insoluble solids are largely of a carbohydrate nature, and consist of cellulose and pentosans for the most part. In the chemical work reported in this paper determinations of the total insoluble dry matter have been made and given as insoluble solids, and consist of those portions of the apple not dissolved by hot water under the conditions prescribed in the method of the Official Association of Agricultural Chemists.[1]

Apples, particularly in the green state, contain small amounts of tannin. In the work here reported no determinations of this have been made, but a few analyses are available from other sources, giving the percentage present. The characteristic flavor and aroma of apples are due for the most part to certain esters or flavoring oils. These exist in the apple in very minute quantities, and though they are of great importance in determining the value and quality of the fruit, no attempt to determine the amount has ever been made, so far as the knowledge of the writer goes. Indeed, it is probable that, owing to the minute quantities present, their determination would be extremely dif-

[1] United States Department of Agriculture, Bureau of Chemistry, Bulletin 107, revised.

ficult, if not absolutely impossible. We can judge of their presence and abundance only by the taste and the aroma of the fruit.

Returning now to a consideration of the changes in the fruit during the four periods of development already mentioned, we find them taking place somewhat as follows. During the period of growth the amount of total solids of course increases greatly. This increase may continue into the ripening period, but after that there is a relative loss of total solids. The percentage, also, of total solids increases during the period of growth and during at least a part of the ripening period, but after that its changes are much dependent upon conditions. The percentage of acid in the fruit is largest in the early stages of growth, and decreases more or less steadily during the entire history of the fruit. The percentage of starch increases during the early part of the growth, and at varying points, under different conditions, it begins to decrease, and disappears during the ripening process. The sucrose increases pretty steadily until the period of after ripening is complete, and then more or less rapidly decreases, and frequently entirely disappears in the process of decay. The point of maximum of sucrose content may be taken as the point of full maturity of the fruit, with a fair degree of accuracy in most cases. The reducing sugars, dextrose and levulose, increase during the period of growth, and may or may not increase slightly during ripening. In the later periods of ripening and decay they in most cases tend to increase, at least until the final stages of decay.

Comparatively little can be said regarding the behavior of the insoluble solids during the periods of growth and ripening. During the periods of after ripening and decay they pretty steadily decrease. Probably they are at their maximum during the early stages of ripening. The stage of development of the insoluble solids of the apple is of great account in determining the quality and condition of the fruit; they compose for the most part the cell walls of the fruit. During the later stages of development of the fruit the middle lamellæ of the cell walls seem to soften, perhaps through the action of some enzym. This

results in a comparatively easy separation of the individual cells from each other and in the mealy taste found in the over-ripe apple.[1]

Comparatively little is known of the behavior of the flavoring oils, but it is evident that they do not develop very noticeably until the period of ripening. It would seem, however, that they develop during the later stages of the ripening period and through the period of after ripening, and tend to disappear as the stage of decay progresses.

Little, also, is known regarding the behavior of the tannin of the fruit, but it is probably highest during the late stages of growth. It may be connected with the development of color in red apples, and inasmuch as it seems to disappear during the ripening stage, when the apple is taking on color, it may be that it contributes in some way to the formation of pigment in the epidermal cells of the fruit.

IV. THE PERFECTLY DEVELOPED APPLE.

In the course of investigation herein reported, the writer has made a somewhat careful study of some twenty varieties of apples, chosen from among the more prominent and widely distributed sorts. From five to fifty or more samples of each variety have been received from many different localities scattered over the entire apple-producing portions of North America. These apples have been carefully examined and their characteristics noted, and from two to twenty samples of each variety have been subjected to chemical examination. In the case of the Ben Davis variety, during the past four years nearly two hundred samples have been received, and fifty or more of these have been given a more or less complete chemical examination. These samples have varied widely in physical appearance and chemical composition. These variations are dealt with in a later division of this paper. The study of these varieties, added to other general observations, has enabled the writer to form a fairly definite conception of them, when developed to their highest perfection in appearance, quality and chemical composition. The point of perfect development is taken as that where

[1] Bureau of Chemistry, Bulletin 94, p. 92.

the after-ripening stage is complete and before any signs of deterioration appear. A variety in this condition is at the point of highest dessert quality. Especial consideration will be given in this discussion to the question of high quality in each variety.

Before entering into this discussion, it may be well to consider the relation between chemical composition and quality. In the first place, it may be said that quality is used with several different meanings. It may refer to the dessert quality of the fruit or to its value for kitchen purposes. The apple of high dessert quality is different from the apple of high kitchen quality. We also speak of the shipping quality of fruit, and high shipping quality is in a measure opposed to high kitchen, and even more to high dessert quality. The apple which ships well will usually be a fair keeper, but these two qualities are by no means coincident. The chemical determinations which throw the most light on quality are those of the sugars and acid and of the insoluble solids, the latter being of greater importance than is usually considered to be the case.

The apple of high dessert quality is low in its content of insoluble solids, this signifying a tender flesh and probably thin-walled cells. It is high in sugars, more particularly sucrose. The amount of acid is proportional to the quantity of sugars; the higher the content of sugars the higher must be the content of acid, in order to bring an agreeable blending of these two constituents. If a large proportion of the sugars is sucrose, the proportion of acid needs to be larger than if the proportion of sucrose is low, in order to give the same quality. The ratio of acid to total sugars most favorable to high dessert quality will vary greatly with individual tastes. Some prefer a sweet apple, and, on the other hand, many like a fairly acid fruit. If the sugars are in the proportion approximately of two-thirds reducing sugars to one-third sucrose, the following may be taken as a fair estimate of the varying ratio of total sugars to acid for different flavored fruits. These ratios will not hold for fruits that have entered into the stage of physiological decay.

	Total Sugars to Acid as Malic.
Sweet apples,	1 : .010 to .025
Mild sub-acid,	1 : .025 to .035
Sub-acid,	1 : .035 to .045
Acid,	1 : .045 to .060
Very acid,	1 : .060 to .085

It has been said that a low percentage of insoluble solids is necessary for high quality in dessert fruits. For cooking purposes this is of minor importance, and the ratio of sugars to acid is narrowed; that is, the relative amount of acid should be larger than in dessert fruits.

Apples of good shipping quality have invariably a high percentage of insoluble solids, and as this is opposed to high dessert quality, it follows that we should not expect to find the highest table quality and highest shipping quality in the same fruit. Most varieties that keep well have a relatively high proportion of their sugars in the form of sucrose. It appears that an apple in order to keep well must be well nourished, and have stored up a large amount of soluble solids, principally in the shape of sugars. Table 1 shows the averages of a number of analyses of most of the varieties that have been examined. In these averages only analyses of normal, well-grown and well-ripened fruit have been included.

TABLE 1. — *Average Analyses of Varieties (Per Cent.).*

	Number of Analyses.	Total Solids.	Insoluble Solids.	Soluble Solids.	Reducing Sugars.	Sucrose.	Total Sugars.	Acid as Malic.	Ratio, Total Sugars to Acid.
Wealthy,	3	13.84	2.11	11.73	7.40	1.71	9.11	.50	1: .055
Maiden Blush,	3	14.59	2.66	11.93	4.80	3.14	7.94	.63	1: .079
Fameuse,	5	15.09	2.64	12.45	7.72	1.38	9.10	.39	1: .043
McIntosh,	6	14.48	2.32	12.16	7.21	1.91	9.12	.38	1: .042
Jonathan,	10	15.19	2.38	12.81	8.28	1.65	9.93	.42	1: .042
Grimes,	11	17.88	2.70	15.18	8.77	4.30	13.00	.45	1: .035
King,	2	16.48	2.45	14.03	8.43	2.39	10.82	.38	1: .035
Rhode Island Greening,	4	15.82	2.89	12.93	6.10	3.27	9.37	.59	1: .063
Northern Spy,	10	14.93	2.39	11.54	8.00	2.22	10.22	.44	1: .043
Baldwin,	9	16.19	2.71	13.48	5.74	3.91	9.65	.55	1: .057
Esopus,	2	17.79	2.67	15.12	7.00	3.66	10.66	.56	1: .053
Yellow Newton,	2	16.48	2.75	13.73	7.59	3.07	10.66	47	1: .044
Winesap,	7	17.42	2.71	14.71	10.02	2.20	12.22	.47	1: .038
Stayman Winesap,	3	15.83	2.78	13.05	8.11	3.44	11.55	.52	1: .045
Rome Beauty,	3	15.72	2.89	12.83	6.77	3.16	9.93	.41	1: .041
Smith Cider,	2	17.37	3.30	14.07	7.54	2.37	9.91	.51	1: .051
Roxbury Russet,	4	18.73	2.82	15.91	7.43	4.85	12.28	.59	1: .048
York Imperial,	7	14.69	2.69	12.00	7.96	3.04	11.00	.39	1: .035
Ben Davis,	11	15.66	3.07	12.59	6.91	2.95	9.86	.44	1: .045

We may now proceed to the discussion of each of these varieties, and will endeavor to set forth the appearance and quality of these varieties when grown to their highest perfection. The conditions under which perfection is attained, and the effect of unfavorable conditions, are discussed in detail in a later section of this paper. These descriptions are not intended to be complete descriptions of the variety, but should be read in connection with a technical description, if one is not already familiar with the general appearance of the variety.

Wealthy. — Well-grown Wealthies should be about 75 to 80 millimeters in diameter and well colored over the entire surface. The color should be a deep, rich red, distributed in the form of stripes and splashes, deepening to a blush on the sunny side. Poor color is a sign of imperfect development in this fruit. The apple should be very symmetrical in form and appearance. It is altogether a handsome fruit when well grown. The chemical analysis shows that the variety is low in total solids, a condition that we find in most summer and early fall varieties. It is low in all the constituent solids except acid. This high ratio of acid to sugar makes it a good cooking apple, but its low content of insoluble solids makes it acceptable for the table, in spite of its rather low content of sugars.

Maiden Blush. — The well-grown Maiden Blush is of about the same size as the Wealthy, of a clear waxen yellow color, with a generous bright red blush on the sunny side. It is fairly high in solids, and, for a fall apple, is especially high in sucrose. The total sugars are, however, rather low, and the insoluble solids and acid high. Its chemical analysis indicates it to be a good cooking apple and fairly good for table use for those preferring an acid fruit.

Fameuse. — Fameuse should attain a diameter of at least 70 millimeters, and a deep red, almost crimson color, over nearly its entire surface. Its chemical analysis shows its excellent table quality, although the percentage of insoluble solids is somewhat high. The relation of sugars to acid is good. It is remarkably low in sucrose and not particularly high in total sugars.

McIntosh. — The McIntosh should grow a little larger than

the Fameuse, reaching about 80 millimeters. The color should be a deep, rich crimson, a little lighter on the shady side and showing sometimes rather obscure splashes and stripes. This variety is one of the most highly esteemed as a dessert fruit. The low content of insoluble solids is in accordance with this estimate, though it does not express fully the excellent texture of this variety. Neither does the analysis give indication of its agreeable aroma and flavor. The content of sugars is good for a variety of its season and the ratio of acid is excellent. The analysis in many ways closely resembles that of the Fameuse, thus indicating the relationship considered to exist between the two varieties.

Jonathan.— This is a favorite table apple of high quality. It should attain a diameter of 70 to 75 millimeters and be of a deep rich straw yellow, almost completely covered with a deep, rich crimson blush. It is a very handsome apple when well grown. Its tender flesh is indicated by its low content of insoluble solids. It is only fairly high in sugars even for a variety of its season, and on this account lacks the richness of flavor of the Grimes and Roxbury Russet. Its ratio of sugars to acid places it among the sub-acid varieties.

Grimes. — Grimes when well grown should reach a size of 75 to 80 millimeters or more, and should be, when ripe, a clear waxen yellow, and may be covered with a slight russeting over the entire surface. When grown in dry climates this russeting may appear in only a slight degree or not at all, a condition which perhaps adds to the good appearance of the fruit. The Grimes is remarkable for its high content of total solids, largely in the form of sugars, and of these a large proportion is in the form of sucrose. The last fact, together with its rather low content of acid, accounts for the almost sweet taste of this variety.

King. — The King when well grown should be not less than 80 to 85 millimeters in diameter, and may be quite variable in form, but should be colored over its entire surface with a deep, rich red, somewhat splashed and mottled. Inasmuch as only two samples of this variety were analyzed, less dependence can be put on the figures given than could be if a larger number had

been examined. Its high quality is shown in its analysis, but it is due to no one constituent. The King is good in every respect. It is a more acid apple than the Grimes, although the ratio of sugars to acid is the same. This is due to the fact that a smaller proportion of the sugars is in the form of sucrose.

Rhode Island Greening. — The Rhode Island Greening should reach a size of about 85 millimeters and possess a clear, greenish-yellow skin. It may show a faint red blush on the sunny side, although this character may not appear in fruit that is otherwise well developed. It is generally considered a variety of excellent cooking quality, and this is shown in its high ratio of acid to sugars and in its relatively high sucrose content, while its high content of insoluble solids does not detract from its value for this purpose.

Northern Spy. — The Northern Spy is reputed to be one of the highest quality of winter varieties. It should reach a size of 80 to 85 millimeters, and be well covered with bright red stripes and splashes. Spies of poor color are frequently, though not always, of inferior quality, depending on the nature and cause of the inferiority. The low content of insoluble solids of the Spy is in accordance with its well-known tenderness of flesh and the readiness with which it bruises.

Baldwin. — The Baldwin should reach a size of 75 to 80 millimeters, and be of even deeper color and more evenly distributed. It is a better shipping apple than the Spy, but hardly as good for the table. This condition of affairs is indicated in its higher percentage of insoluble solids. It is also higher in sucrose and in the ratio of acids to sugar.

Esopus. — This variety should reach a diameter of 75 millimeters at least, and the skin should be a deep, rich straw yellow, almost completely covered with deep, rather dull red splashes and stripes. This, like the Jonathan, often appears with a poor color, indicative of imperfect development. The Esopus stands among the best as an all-round high quality variety, and its chemical analysis is in accord with this. It is about medium in its content of insoluble solids, indicating that it is sufficiently firm of flesh to ship and cook well, but not enough to seriously

injure its table quality. It is about medium in sugars and the relative amount of sucrose is fairly high. Its ratio of sugars to acid places it among the more acid table fruits and less acid cooking varieties.

Yellow Newtown. — The Yellow Newtown should be from 80 to 85 millimeters in diameter, of a clear, greenish-yellow color, sometimes slightly blushed on the sunny side, and may often show over a considerable portion of the surface a grayish scarf skin characteristic of the variety. Its analysis indicates it to be of somewhat firmer flesh than the Esopus and somewhat less acid; otherwise, it is very similar in its constitution.

Winesap. — The Winesap should be about 75 millimeters in diameter, and should be deeply colored, although the color is hardly as dark as that of Jonathan. It should, however, when well grown, show little or no signs of the ground color of the fruit. Its analysis places it in the highest class. It is rather high in insoluble solids, but very high in sugars, being exceeded only by the Roxbury and Grimes. However, a smaller portion of the sugar is in the form of sucrose than in either of the other two sorts.

Stayman Winesap. — This variety is quite similar to the Winesap. It should reach a little larger size and is not quite as red in color. The ratio of acid to sugars is somewhat higher, but this excess of acid is obscured by the higher amount of sucrose, so the acidity of the apple is about the same to the taste.

Rome Beauty. — As only three samples of this variety have been examined we do not feel like venturing on any very positive statements in regard to it. It would seem to reach a size of 80 millimeters and a color somewhat less marked than other red varieties. It shows a relatively high proportion of sucrose, but is only fair in the amount of total sugars. It is rather high in insoluble solids to be a good table fruit, and altogether the analysis is not indicative of very high quality.

Smith Cider. — The same remarks concerning the study of the Rome Beauty will apply to this variety. Very few samples have been examined, and how typical the analysis given is,

the writer does not feel confident. It is remarkably high in insoluble solids, but whether this characteristic is constant or not will require further study to determine.

Roxbury Russet. — The Roxbury Russet should reach a size of 75 to 80 millimeters. The amount of russeting is dependent on climate. A moist atmosphere during the early stages of growth seems to contribute to the increase of russeting. Its analysis shows a high content of sugar, a large proportion of which is in the form of sucrose. It is also high in acid, but in view of the amount and form of the sugars it is not particularly acid to the taste. It is high in insoluble solids, indicating firmness of flesh and good shipping qualities. Altogether, it is one of the high quality varieties, as indicated by its chemical composition.

York Imperial. — The York Imperial should reach a size of about 80 millimeters, and be of a clear waxen yellow, partially overlaid with a pinkish red. Sometimes this over color deepens to a moderately dark red, but this is not necessary to the attainment of high color and pleasing appearance. Its analysis indicates its sub-acid flavor, and it shows as low a ratio of acids to sugars as any of the varieties here reported.

Ben Davis. — The Ben Davis should attain a diameter of 75 millimeters, and fairly deep red color over almost its entire surface. Partial coloration in this variety is a sure sign of imperfect development. It enjoys the reputation of being one of the best varieties to ship and keep, and one of the poorest for both kitchen and table uses. This opinion is supported by its chemical analysis. It is especially high in insoluble solids and low in everything else, although the proportion of sugar in the form of sucrose is fairly high. The total sugars, however, are low for a winter variety. Its serious deficiency as a table fruit is its high insoluble solids content, and as a kitchen fruit its low ratio of acids to sugar.

V. THE INDIVIDUALITY OF THE TREE.

The question of the individuality of the tree has already been mentioned (see page 179). The careful measurements that have been made of the apples from several Ben Davis and Baldwin

trees for the past three years afford some interesting data on this point. The trees are on nearly level land at the top of a slope. The soil is a uniform gravelly, clay loam, and the trees are of the same age, and vary only a little in size. In the years 1908–10, every apple borne to maturity by these trees has been measured, as described in the last report of this station,[1] and the results for the individual trees are presented in Table 2.

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[1] Report Massachusetts Experiment Station, 1910, p. 198.

TABLE 2. — *Apples from Different Trees.*

	Number of Apples.	Size. Mean.	Size. Standard Deviation.	Size. Coefficient of Variability.	Form. Mean.	Form. Standard Deviation.	Form. Coefficient of Variability.
Davis.							
Tree 2: —							
1908,	864	71.02±.14	6.16±.10	8.67±.14	1.1422±.0014	.0576±.0009	3.04±.08
1909,	251	70.89±.22	5.40±.16	7.62±.18	1.1248±.0024	.0553±.0017	4.91±.15
1910,	425	73.15±.19	5.69±.13	7.78±.15	1.1159±.0016	.0516±.0012	4.62±.12
Tree 3: —							
1908,	567	68.80±.15	5.31±.11	7.72±.16	1.1399±.0016	.0543±.0011	4.73±.09
1909,	343	68.48±.19	5.24±.13	7.65±.22	1.1297±.0020	.0553±.0014	4.89±.19
1910,	449	72.27±.19	6.01±.13	8.32±.22	1.1322±.0015	.0488±.0011	4.31±.11
Tree 5: —							
1908,	469	68.35±.13	5.55±.08	8.12±.13	1.1666±.0019	.0626±.0013	3.76±.08
1909,	155	68.32±.27	4.96±.18	7.26±.33	1.1295±.0028	.0519±.0019	4.59±.19
1910,	360	75.53±.21	5.88±.15	8.00±.22	1.1151±.0018	.0512±.0013	4.59±.12
Tree 7: —							
1908,	423	72.80±.18	6.45±.13	8.86±.17	1.1716±.0019	.0578±.0013	3.37±.07
1909,	431	70.37±.17	5.12±.12	7.28±.19	1.1486±.0017	.0511±.0012	4.45±.11
1910,	587	75.12±.19	6.85±.14	9.12±.21	1.1333±.0014	.0516±.0010	4.55±.09
Tree 8: —							
1909,	686	70.45±.13	4.93±.09	7.00±.13	1.1310±.0013	.0494±.0010	4.37±.09
1910,	1,093	72.57±.09	6.16±.06	8.52±.10	1.1211±.0007	.0481±.0005	4.29±.05
Baldwin.							
Tree 2: —							
1909,	321	78.62±.21	5.59±.15	7.11±.23	1.1615±.0022	.0579±.0015	4.98±.13
1910,	287	78.84±.23	5.86±.16	7.43±.27	1.1745±.0021	.0536±.0015	4.56±.15
Tree 4: —							
1909,	621	74.39±.14	5.01±.10	6.73±.15	1.1848±.0014	.0523±.0010	4.41±.10
1910,	189	76.90±.27	5.57±.19	7.24±.30	1.1834±.0027	.0553±.0019	4.67±.17
Tree 5: —							
1909,	319	77.66±.21	5.66±.15	7.29±.22	1.1790±.0024	.0644±.0017	5.46±.16
1910,	546	77.71±.15	5.20±.11	6.69±.15	1.1888±.0018	.0622±.0013	5.23±.12

A study of this table shows some positive signs of individuality in the trees in the characters of size, form and productiveness. Size is of course considerably affected by the number of apples borne, though not as much as usual in this case, as the trees have not matured a very heavy crop during the period of observation. The marked seasonal fluctuation in size will be considered later. We can say that Ben Davis trees 7 and 2 show a tendency to bear large apples and trees 3 and 5 a tendency to bear smaller fruit, though in 1910 tree 5 bore the largest fruit of any, but at the same time the crop was lightest of all. Among the three Baldwins, the rank has been the same each year, in spite of the fluctuations in productiveness. In variability there are no constant differences. In the Ben Davis there seems to be a relation between variability and number of apples produced, the greater the number of apples the greater the standard deviation and coefficient of variability, — a relation that is to be expected.

In form, the situation is much the same. Ben Davis tree 7, which produced the largest apples, has invariably borne the flattest ones, usually by a considerable margin. Tree 2 shows a fairly constant character of producing more elongated apples than its fellows. In the Baldwins, also, there are signs of slight differences between the trees.

The variation in number of apples borne by the different trees is great. Ben Davis tree 8 has averaged about three times as many apples as tree 5, and they have been larger. A part of this difference is due to the fact that tree 8 is somewhat larger than tree 5, but the difference in size is not enough to account for all the difference in productiveness.

Productiveness is one of the most important qualities of a variety or individual tree. If the tree does not produce at least a fair crop of fruit, all other valuable qualities it may possess lose their attractiveness to the commercial grower, while great productiveness covers a multitude of deficiencies. Other investigations, and common observations as well, have shown very marked differences in the bearing ability of different trees.[1] In our opinion, these differences, as well as any others which may occur, are generally due to one or more of four influences:

[1] See Macoun, Report Central Experiment Farm for 1903, p. 102.

(1) differences in soil, (2) differences in aspect or exposure, (3) some inherent quality of the tree, (4) the influence of stock.[1]

That the first two of these cause difference no one will dispute, but there are many variations which can hardly be explained by differences in soil or site. It has been assumed by many that variations in productiveness arise from within the tree, and are transmissible. We know of no direct evidence to support this view. Inheritable variation in color and form has appeared in certain varieties. The Collamer, Banks and possibly Gano apples are instances of the former, and a probable case of the latter has been reported by the writer.[2] Whether the slight differences in form and size reported here are transmissible by bud is by no means certain. We are of the opinion that they are not, for it seems possible to explain these and the other variations in productiveness, not attributed to soil and site by reference to a different cause.

Waugh has shown that in plums different stocks produce marked modification in the trees grown on them.[3] Apple stocks do not differ as widely as do the plum stocks, above referred to, but the observed differences are also less marked. Every apple tree of a named variety is growing on a stock of a different, unnamed variety, *i.e.,* a seedling. These seedlings differ to a considerable degree. May not the slight differences observed between individual trees of a variety, growing under apparently similar conditions, be largely due to the influence of the seedling root? We know of no direct evidence to support this view, but to us it seems a more promising theory than that of individuality of the different buds.

If this supposition is true, it is probable that the production of the most desirable trees of a given variety would be favored by growing on a particular known root; thus the Baldwin grown on roots of Spy, Wealthy or Siberian Crab might be an especially desirable tree, while if grown on Tolman or King[4] it might be less desirable. Different soils and localities might be

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[1] There are, of course, large seasonal fluctuations in productiveness due to conditions peculiar to the different years. These are not considered in this discussion.

[2] See Report Massachusetts Experiment Station, 22, Part II., p. 187.

[3] Report Massachusetts Experiment Station, 21, Part II., p. 174.

[4] The varieties mentioned are random selections for illustration. There is no reason to believe that they would influence the Baldwin as indicated.

suited by different stocks. We know of no experiments to learn what are the preferences of different varieties or soils, but it appears to be a desirable and promising line of investigation.

VI. THE MODIFYING EFFECT OF CLIMATE ON THE DEVELOPMENT OF THE APPLE.

On Form.

In the last report of this station [1] the question of the variation in form of the Ben Davis was dealt with to some extent, but without arriving at any very definite conclusion as to the cause, further than that it was climatic and closely related to the nearness of large bodies of water. Since this report was written, two years' further work have been completed, which serve to emphasize the conclusions mentioned above, and to show, further, that there are large seasonal fluctuations in the index of form. The following figures from a few selected stations will illustrate this: —

TABLE 3. — *Seasonal Variation in Form.*

	Number of Apples.	Mean Index of Form.	Standard Deviation.	Coefficient of Variability.
Charlottetown, P. E. I.: —				
1907,	74	1.0511±.0049	.0619±.0034	5.88±.31
1908,	122	1.1250±.0052	.0858±.0037	7.63±.33
1910,	135	1.0557±.0043	.0744±.0031	7.05±.29
Abbotsford, Quebec: —				
1907,	151	1.1788±.0039	.0735±.0028	6.23±.24
1908,	129	1.1739±.0041	.0683±.0029	5.82±.23
1909,	184	1.1986±.0031	.0628±.0022	5.24±.21
1910,	115	1.1356±.0029	.0455±.0021	4.01±.18
Isle la Motte, Vt.: —				
1907,	203	1.1547±.0024	.0735±.0024	6.28±.27
1908,	170	1.1406±.0027	.0526±.0020	3.74±.15
1909,	148	1.1475±.0033	.0590±.0023	5.14±.24
Amherst, Mass.: —				
1907,	284	1.1656±.0023	.0581±.0017	4.98±.14
1908,	2,321	1.1515±.0008	.0589±.0006	5.29±.05
1909,	1,866	1.1338±.0009	.0527±.0006	4.65±.06
1910,	2,914	1.1238±.0007	.0504±.0004	4.48±.04
Storrs, Conn.: —				
1907,	147	1.1557±.0030	.0534±.0021	4.62±.18
1908,	131	1.1423±.0041	.0689±.0029	6.03±.21
1909,	146	1.1330±.0035	.0622±.0025	5.49±.24
Marblehead, Mass.: —				
1908,	192	1.1021±.0029	.0598±.0021	5.42±.18
1910,	176	1.0982±.0033	.0651±.0023	5.93±.22
Sandwich, Mass.: —				
1908,	162	1.1281±.0021	.0407±.0015	3.67±.14
1909,	143	1.1167± 0036	.0654±.0025	5.86±.24

[1] Report Massachusetts Experiment Station, 22, p. 194 (1909). The reader is referred to this paper for the methods used in measuring and studying this variation in form.

This has led to a study of the differences in the climatic conditions in the different years. The apple during its early stages of growth, following blossoming, is relatively more elongated than is the mature fruit. During the later periods of growth it enlarges in cross diameter relatively more. A study of the temperature during the latter part of the summer failed to show any differences corresponding to the variations in form. An examination of the daily mean temperatures for a period at and following the blossoming period gave more positive re-

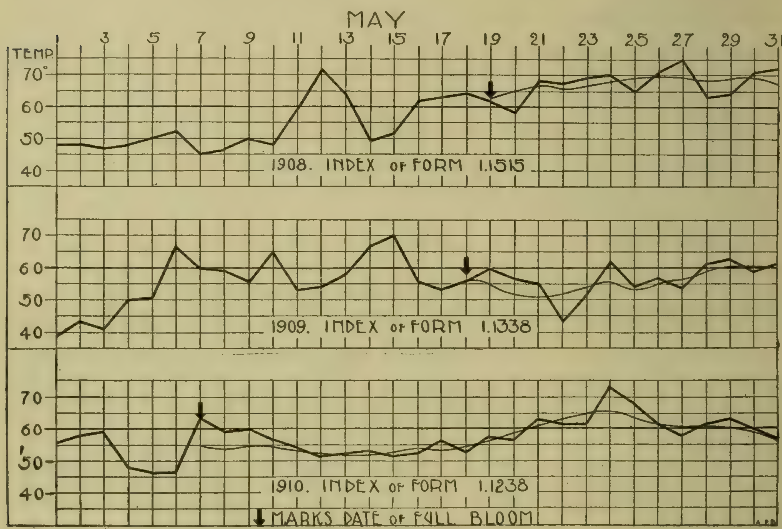

Fig. 1.

sults. At Amherst the apples measured in the last four years have been successively more and more elongated. The temperatures during the blossoming season for the last three years are shown in Fig. 1. The date of full bloom and index of form are also shown. We do not know the date of full bloom in 1907. An examination of this chart shows that the temperature for a period of two or three weeks following blossoming has been lower each year, in agreement with the greater elongation of the fruit.

We have data for a number of other stations, and all show a similar correspondence of temperature and form. Fig. 2 shows

conditions in the Lake Champlain valley, the apples being from Isle la Motte, Vt., and temperature data from Burlington. We

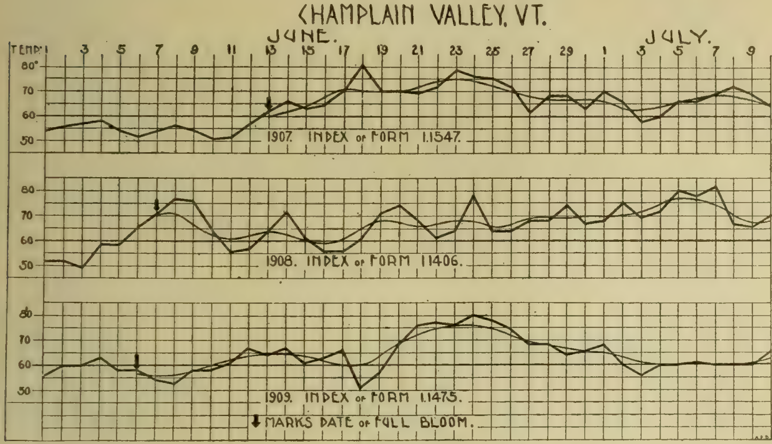

Fig. 2.

do not know the date of bloom in 1908, but it was probably not far from June 8. In Fig. 3 the temperature data are from

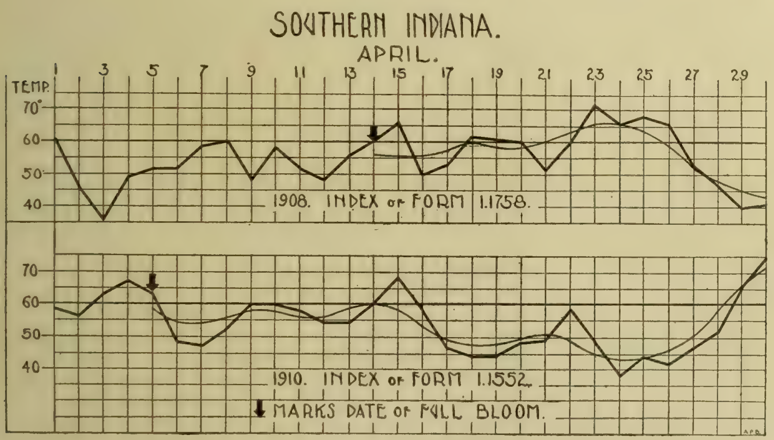

Fig. 3.

Salem, Ind., and the apples from Mitchell; in Fig. 4 both apples and temperature data are from Bentonville, Ark.

An examination of these charts shows a reasonably close agreement with that for Amherst. A period of cool weather,

probably during a space of two or three weeks, results in greater elongation of the fruit, presumably through a prolongation of the period of relatively greater axial elongation before referred to.

This theory explains not only the seasonal variations but the greater elongation in the vicinity of large bodies of water, for the fact that in such locations the weather is relatively cool during the spring needs no discussion. In this connection we have observed that the seasonal fluctuation in form is less near

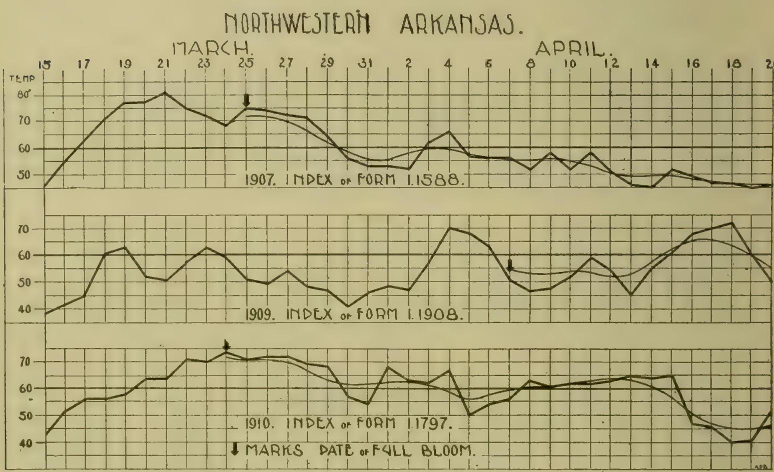

Fig. 4.

the great lakes and the ocean than at a distance from them, this showing the influence on the form of the apple of the equalizing effect on the temperature of the large bodies of water.

In gathering the apples from the trees under observation in Amherst, they have been divided into four lots, by bisecting the tree with a perpendicular plane running east and west, and again with a horizontal plane about midway of the head of the tree. This divides the tree into quarters designated upper south, lower south, upper north and lower north. The sections of each tree have approximately equal amounts of bearing wood. From the first these different portions of the tree have shown differences in form which have been meaningless and confusing until the theory of the temperature following blossoming was

proposed. If this is the correct solution we ought to expect the upper south portions of the tree, owing largely to its exposure to the warmth of the sun, to give the flattest apples, and the lower north to give the most elongated ones, with the other two portions intermediate. The calculations for the three years 1908–10 are shown in Table 4.

TABLE 4. — *Variation in Form in Different Parts of the Tree.*

	Number of Apples.	Mean Index of Form.	Standard Deviation.	Coefficient of Variability.
Ben Davis.				
Upper south: —				
1908,	518	1.1643±.0017	.0593±.0012	3.61±.07
1909,	552	1.1390±.0015	.0520±.0011	4.57±.10
1910,	707	1.1299±.0013	.0500±.0009	4.43±.09
Lower south: —				
1908,	714	1.1512±.0015	.0619±.0011	4.19±.07
1909,	379	1.1302±.0018	.0516±.0012	4.57±.12
1910,	893	1.1249±.0011	.0489±.0009	4.35±.08
Upper north: —				
1908,	414	1.1553±.0020	.0607±.0014	3.91±.08
1909,	305	1.1333±.0020	.0509±.0014	4.40±.14
1910,	576	1.1216±.0016	.0544±.0010	4.85±.10
Lower north: —				
1908,	676	1.1406±.0016	.0644±.0011	4.58±.07
1909,	287	1.1338±.0021	.0529±.0015	4.67±.14
1910,	869	1.1171±.0012	.0505±.0008	4.52±.08
Baldwin.				
Upper south: —				
1909,	467	1.1877±.0019	.0606±.0013	5.10±.13
1910,	235	1.1955±.0024	.0537±.0016	4.49±.16
Lower south: —				
1909,	290	1.1688±.0020	.0500±.0014	4.28±.14
1910,	137	1.1792±.0031	.0536±.0022	4.57±.20
Upper north: —				
1909,	327	1.1809±.0020	.0548±.0014	4.64±.13
1910,	168	1.1792±.0030	.0575±.0021	4.88±.18
Lower north: —				
1909,	177	1.1586±.0026	.0522±.0019	4.51±.18
1910,	86	1.1717±.0044	.0602±.0031	5.14±.31

The relative rank of the different parts of the trees of the Ben Davis is as follows: —

	1908.	1909.	1910.
1. Most flattened,	Upper south.	Upper south.	Upper south.
2,	Upper north.	Lower north.	Lower south.
3,	Lower south.	Upper north.	Upper north.
4. Most elongated,	Lower north.	Lower south.	Lower north.

It is seen that the upper south quarter of the tree yielded the flattest apples each year, and usually by a considerable margin, while the most elongated fruit comes from the lower portion of the tree, and, in two of the years under consideration, on the north side. On the whole the figures for the different parts of the tree support the theory already presented that the elongation is due to relatively cold weather, and gives support to the idea that the heat of the sun has much to do with the temperature of the tree itself and probably the development of the fruit.

In the Baldwins the relative rank is as follows for both years: upper south, upper north, lower south, lower north.

On Size.

The size of an apple is determined by several factors. Each variety has its individuality in this respect. Culture is important, an abundance of nitrogenous fertilizers and an abundant supply of moisture being favorable to the attainment of large size. An excessively heavy crop prevents the development of full size of the individuals, but a light crop does not seem favorable to any larger fruit than a moderate one. Young trees usually bear larger fruit than mature ones, while in very old trees the fruit is commonly inferior in size. The differences due to age are probably in considerable degree at least due to the influences already mentioned.

Aside from these influences the summer temperature seems to have considerable influence. Some evidence on this point was presented in an earlier paper.[1] Table 4 (page 203) gives further data on this point.

The mean summer temperatures at Amherst were as follows: 1908, 58.8°; 1909, 56.7°; 1910, 58.9°.

The size of the apples is in a general way in accordance with these temperatures.

In 1910 the apples were much larger than in 1908, while the temperature was practically the same. This may be due to increased amounts of fertilizer which have been applied. The orchard was limed in the spring of 1909, and this may have had

[1] Report Massachusetts Experiment Station, 22, pp. 204, 211 (1909).

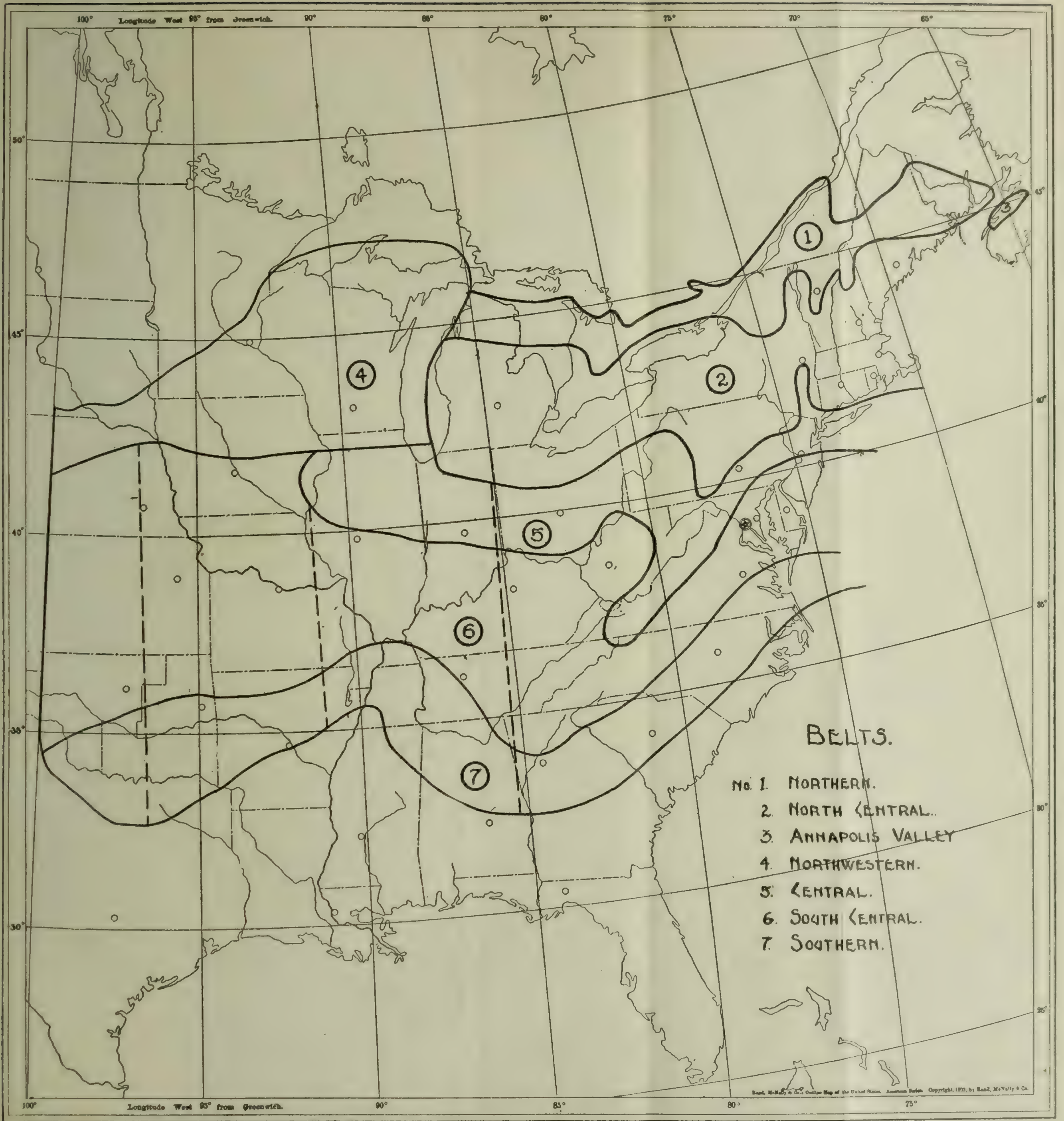

FIG. 5.—APPLE BELTS OF NORTH AMERICA.

an effect by liberating increased amounts of plant food. It does not seem possible to account for the increased size by temperature conditions.

Data from other localities similar to that previously published might be presented, but inasmuch as they show no new features, it is deemed unnecessary to do so.

On General Development.

The question of variation in form and size having been especially considered, we may now proceed to a consideration of the differences in the general development of different varieties, with more particular reference to color, keeping quality and table quality. These are the characters of paramount importance in determining the commercial value of a lot of apples. In order to discuss these questions we have found it convenient to divide the country into belts.

Apple Belts of North America.

We find in pomological writings frequent mention of different apple "belts," such as the Baldwin belt or the Ben Davis belt. This term is understood to designate a certain area over which the variety named is the leading one grown. We find many other varieties referred to a given belt, as the Northern Spy and Rhode Island Greening, which are referred to the Baldwin belt. In connection with the work herein reported, and for convenience in the discussions, the writer presents the division of North America into apple belts, shown in Fig. 5.

1. The northern belt, in which the Fameuse is the most characteristic sort.

2. The north central belt, perhaps the most recognized of any. It is characterized by the Baldwin, Northern Spy, Rhode Island Greening, Hubbardston and many others. It comprises the oldest and in some ways best understood portion of the apple region of North America.

3. The Annapolis valley, in which we find varieties similar to the second belt, but where the season is shorter and many of the varieties of the second belt do not mature well.

4. The northwestern belt, comprising the States of Minnesota and Wisconsin and adjacent territory; somewhat like the Baldwin belt to the east, but having winters too severe for many of the varieties of that belt. It is characterized by the Oldenburg, Wealthy, Hibernal, Northwestern Greening and many others.

5. The central belt, which is of less importance. There is no one variety that predominates over the whole of this territory. In eastern sections we find the Yellow Newtown, Smith Cider and Fallawater, and west of the mountains the Rome Beauty.

6. The south central belt, one of the largest and most important. There are three varieties that are quite generally spread over this belt, the Ben Davis, Winesap and York Imperial. The Grimes is quite general and important in the western part, also the Jonathan.

7. The southern belt, which extends to the southern limit of apple growing, and is characterized by the Yates, Terry, Shockley and Horse as leading varieties.

The figure shows these belts somewhat roughly. They depend on latitude and altitude more than anything else. Inasmuch as the altitude along the Appalachian Mountains is variable, it is impossible to show the belts with entire accuracy. Each belt will dip further south than is indicated in the higher elevations of this region. Some varieties are found generally distributed through the entire range of its belt from east to west. Others do not extend the entire length. The western portion of the territory covered has a smaller precipitation, and this may affect some varieties. More important than this, however, are the higher summer temperatures which prevail, and which cannot be successfully withstood by some varieties grown in the east. Other varieties succeed even better in this warmer summer climate than they do in the cooler and more humid east. The dotted lines in the figure show a possible division of the belts, but such division is not very definite nor of great value. No attempt is made to map the Rocky Mountain and Pacific Coast apple region, owing to the fact that the distribution of varieties there is governed largely by elevation, and would be very difficult to map, especially on so small a scale as the figure shows.

Distribution of Varieties.

A few varieties, most of them well known and of rather general distribution, have been selected for a special study in connection with this work. We may now proceed to a discussion of the distribution and some of the characteristics of these varieties.

Oldenburg. — This variety extends over almost the entire apple-growing region of North America. We find it recommended as a commercial variety in some region of every apple belt shown in Fig. 5, with the possible exception of the southern. The two principal reasons for the wide distribution of this variety are its extreme hardiness, which enables it to withstand the severe winters of the far north, and the short season of maturity, which enables it in the south to ripen before the hot periods of July and August. In addition to this it is an early, regular and fairly abundant bearer, and not particularly subject to disease and insect injuries, and the fruit stands handling quite well.

FIG. 6.[1]

[1] Figs. 6 to 14 are intended to show the territory over which the various varieties have been recommended as desirable commercial sorts. The places of origin of each variety, so far as known, is indicated by a cross.

Wealthy. — The Wealthy is a fall apple of rather wide distribution. It is growing in favor, especially as a filler in new orchards, and its territory of cultivation is spreading. It originated in Minnesota, and finds its highest favor in the northwestern belt. It also succeeds perfectly over a greater part at least of the north central belt. It is cultivated somewhat in New Jersey, but does not find favor south of there. It will mature a little farther north than the Baldwin, and is not subject to winter-killing as is the Baldwin in severe winter temperatures. It is found in greatest perfection through southern New Hampshire and Massachusetts, and along a line passing west just south of Lake Ontario and through the Province of Ontario, south central Michigan and southern Wisconsin.

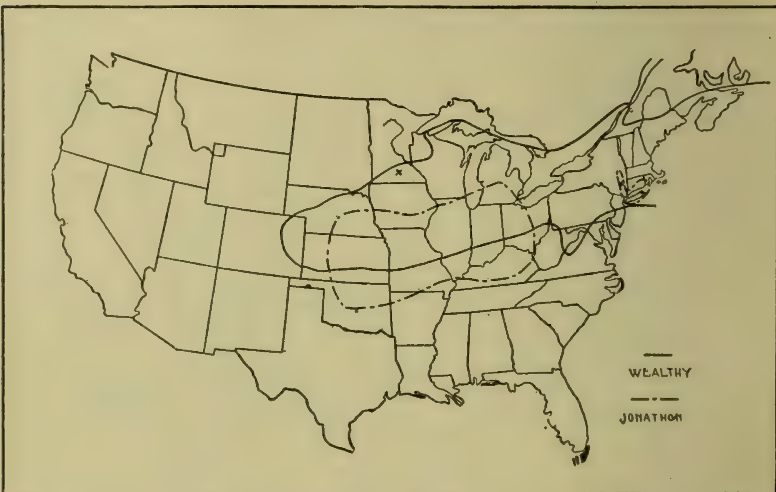

FIG. 7.

Wolf River. — The Wolf River is reputed to be a seedling of the Alexander, one of the Russian varieties, and it may serve as a type of this class of apples. It is of Wisconsin origin and has attained high favor in that State. It appears to succeed best in the central and northern parts of the northwestern belt, in the northern part of the north central belt and the southern part of the northern belt. When grown too far south it does not keep well, is apt to become mealy and tasteless and is of general

inferior quality. The Russian varieties as a class are reputed to be of poor quality. They are not of the highest quality, but much of their reputation for inferiority results, in our opinion, from their being grown too far south. As a class they belong to the northern frontier of apple growing, and when grown there, many of them are equal to the better varieties of the more southern apple regions.

Maiden Blush.— This variety is a fall sort, originating in Burlington, N. J., in which State it has attained its highest

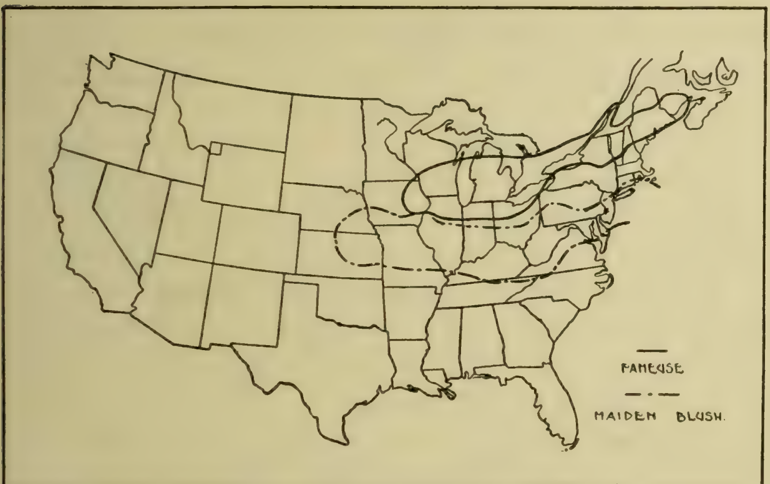

Fig. 8.

favor. It is grown with success as far north as Long Island and southern Connecticut, and west through southern Indiana and central and southern Illinois. It does not withstand the dry climate of the plains as well as some others, but reaches as far west as eastern Nebraska and Kansas. It is cultivated successfully south into the mountains of Virginia. Gould says: —

On Cecil sandy loam, at 900 to 1,000 feet elevation, it is inclined to rot severely, but on the more clayey soil of the Piedmont regions it does well. Its season of ripening varies considerably, ranging from summer to early fall. In the middle Piedmont orchards it would probably ripen in August or early September. At one point in North Carolina having an altitude of 3,500 to 4,000 feet, with rather less friable loam, some very fine specimens have been seen the middle of October.[1]

[1] Bureau of Plant Industry Bulletin 135, p. 38.

It will be seen that the Maiden's Blush belongs to the central belt and the northern part of the south central belt.

Fameuse. — The Fameuse is one of the most northern of commercial apples. It is grown in most parts of the northern belt, also in northern Indiana and Illinois and in southern Michigan, though in these regions the variety does not attain the quality of the St. Lawrence and Champlain valleys. It becomes a fall apple, and is of poor color and inferior flavor. Specimens received from Prince Edward Island were dull red and green, and small in size, while those from southern Quebec were very good specimens of the variety.

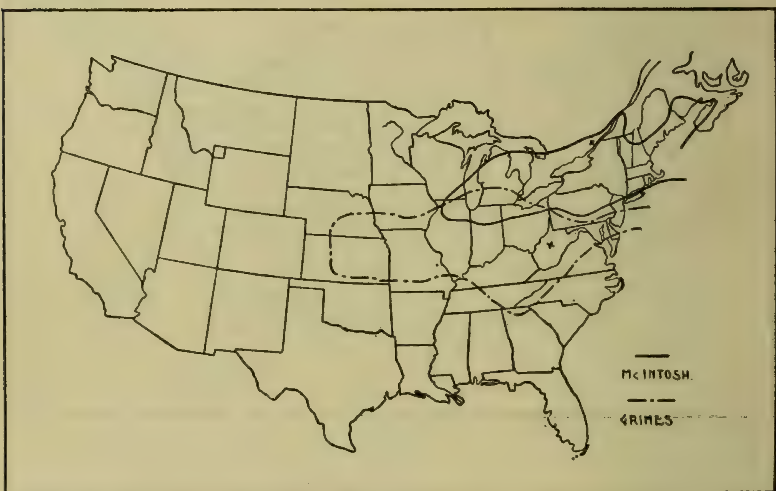

FIG. 9.

McIntosh. — The McIntosh is similar to the Fameuse and succeeds in similar territory. It does well further south, however, being at its best in south central New England and western New York. While it has been known a long time, it has not attained great favor as a commercial variety until recently, probably on account of its susceptibility to the apple scab, which has heretofore been difficult to control in a satisfactory manner. It is now gaining rapidly in popularity, and the territory of its culture is spreading. It is not grown to any extent west of Michigan, excepting in the far northwest. Throughout the Baldwin belt it is a fall apple, and south of this it becomes a

late summer or early fall variety, and is inferior in flavor and color to those grown farther north. Beach says: —

> It is adapted to a wider range of localities than is the Fameuse. . . . In western New York it cannot be expected to keep much later than October in ordinary storage without considerable loss, but in cold storage it may be held until December or January. When grown in more northern or elevated regions it is often held in good condition until mid-winter or later.[1]

Jonathan. — This variety had its origin in the Hudson valley, where it is now grown to a considerable extent, as well as in Long Island and southern Connecticut. It is a favorite in the south central belt west of the mountains and in favored portions of southwestern Michigan. It is at its best in central Illinois, northern Missouri and eastern Kansas and Nebraska. In Virginia and North Carolina it seems to succeed best at elevations of 1,200 to 1,500 feet or more. It has received considerable favor in the intermountain and pacific northwest apple regions, where conditions are similar to those in the regions already mentioned. It requires good care and a fairly rich soil in order to develop to its best. It should receive more attention from growers in regions where it succeeds well. It loses its sucrose in storage more readily than most varieties, after which, while still of good desert quality, it lacks the richness possessed by apples high in sucrose. It is necessary to harvest this variety at the proper time of maturity. If allowed to hang too long on the tree, especially if the weather is warm, it develops the defects of overripe apples, and will not keep well.

Grimes. — Grimes is an old Virginia apple which has spread very generally over the south central belt. It is well known over nearly all of this territory, especially in the western portion of it. Its culture extends west to central Nebraska and eastern Kansas. In the northern portion of this belt it is a late fall and early winter apple; in the southern portion it is more strictly a fall variety. It is grown to some degree north of the territory indicated, being found frequently in southern Michigan. In its more northern locations it is smaller than in

[1] Apples of New York, Vol. 1, p. 133.

the south and more acid, the latter being a quality that is appreciated by some, inasmuch as in the south the variety has a mild subacid flavor. Gould says: —

> An orchard twelve to fifteen years old in Bedford County, Va., on Porters clay, at 1,500 feet elevation, with southeast exposure, produces fruit of unusual excellence, notable for its good size, fine yellow color, crispness of texture, and rich, spicy flavor. This orchard has had hardly fair care. The fruit of this variety from it reaches edible maturity early in October, but possesses good keeping qualities for the variety. On the same farm, at a point having somewhat lower elevation and a looser type of soil, it matures considerably earlier, and is not of such excellent flavor as from the location above mentioned. Produced at elevations of 2,000 feet in the upper sections of the Blue Ridge region, it may be kept under fairly favorable conditions until early winter. . . . At points south of Virginia, at the elevations of the Piedmont region, it is inclined to drop prematurely, but when grown at points having not less than 1,500 feet altitude it is highly prized in its season. One grower in the southwestern part of North Carolina has this variety at 2,500 to 2,800 feet elevation, and also at an altitude 400 to 600 feet higher. It is his experience that the fruit grown at the latter elevation will keep two months longer than that from the lower level. The fruit is also finer in appearance and more satisfactory in every way at the greater elevation. For best keeping qualities it should not be allowed to become too mature before picking.[1]

Favorable reports on it have been received from certain localities in New York, but in general as grown in this State it does not develop in size, color or quality as well as it does in more southern latitudes, and there is a high percentage of loss from drops and culls.[2]

Tompkins King. — The King is a variety found over a limited portion of the north central belt. It is a standard apple in western New York, and is grown in southern Ontario and to some extent in Michigan. It is also a favorite variety in Annapolis valley in Nova Scotia, where it succeeds to a high degree. The tree is weak, and requires high cultivation and good care. It is scarcely known west of Lake Michigan, and is met with scatteringly as far as Virginia, where it is found in the higher levels of the Blue Ridge. The tree is

[1] Bureau of Plant Industry, Bulletin 135, p. 36.
[2] Beach, Apples of New York, Vol. 1, p. 154.

evidently not able to withstand the hot dry summers of the middle west.

Esopus. — This is an old variety, but one that has never been very largely cultivated. This may be partially accounted for by the fact that the tree is not particularly vigorous nor especially productive, and is somewhat susceptible to diseases. The apple is of superior quality, being much better than the Baldwin, which it considerably resembles. It has been grown somewhat in the Champlain and Mohawk valleys. It is an apple of limited cultivation for the Baldwin belt. Gould says, regarding its behavior in Virginia and North Carolina: —

> At lower levels it usually drops prematurely, and even on Porters black loam at 2,000 feet elevation it often rots and drops seriously. At 3,000 to 3,500 feet altitude in North Carolina, on a rather loose loamy soil with porous subsoil containing more or less red clay, it develops more satisfactorily, keeps well into the winter, and does not manifest in any marked degree the defects observed at the lower levels.[1]

It has recently attained high favor with the growers in certain portions of the Pacific northwest. In our opinion this variety is deserving of wider cultivation inasmuch as it is an excellent variety for all purposes. In fact, so far as the fruit goes we believe that none of the better known varieties of commercial apples answers so well the requirements of a general purpose market apple. When well grown it is of good size and attractive appearance, and is adapted for both dessert use and cooking. It is also a reasonably good shipping apple. It requires the better care and higher cultivation which orchards are destined to receive in the near future.

Rhode Island Greening. — The distribution of the Rhode Island Greening is very similar to that of the Baldwin, but is perhaps adapted to somewhat wider range of conditions; being a green apple it does not call for conditions adapted to the production of good color necessary for the Baldwin. It attains better size and appearance than the Baldwin when grown towards the northern limit of its culture. It is possibly somewhat hardier in tree. It is grown all through the north central

[1] Bureau of Plant Industry, Bulletin 135, p. 34.

belt, and extends somewhat further south in the higher elevations. In the south it becomes a fall apple, and is apt to ripen prematurely and drop and sometimes to decay on the trees.

Northern Spy. — This is a variety of the Baldwin belt, and its distribution is very similar to that variety, although less general. It is at its best in the Champlain valley and in western New York. Some excellent specimens have been seen from southern New England, but they do not keep as well as those from farther north. It seems to be somewhat capricious as to soils and culture, and in localities of ill success it is not always possible to determine the cause of the difficulty. When grown

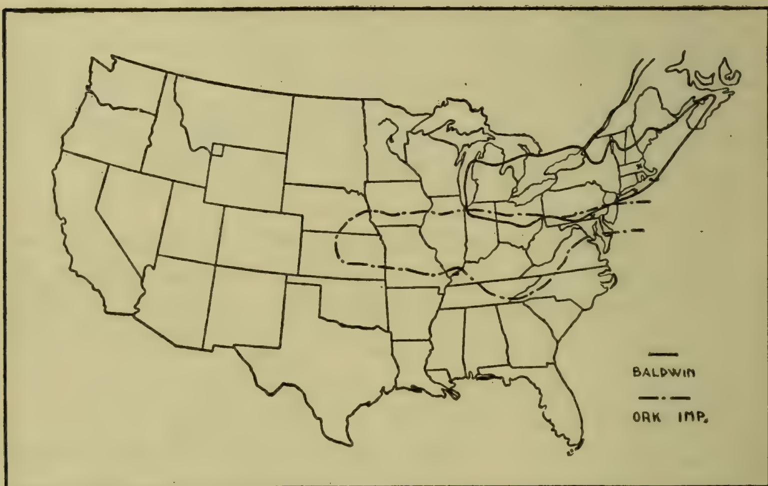

FIG. 10.

in the south it rots badly and drops, nor does it attain the high color and quality that characterize it in its more northern home.

Baldwin. — The Baldwin is the standard winter apple of the northeastern United States. It is distributed all over the north central belt, and is so nearly confined to it as to lend its name to that zone. It is also grown to a considerable extent in the Annapolis valley and very sparingly in the central belt, although it rarely attains any commercial standing in this region. It is not grown west of Lake Michigan, owing to the extremes of maximum and minimum temperatures which there

prevail. In the northwestern belt the winters are too severe and the trees winter-kill; while south of this region the summers are so warm that the variety ripens prematurely and is apt to rot and drop. These same remarks will apply to many other varieties of the Baldwin belt, most of them being too tender to withstand the winters west of Lake Michigan. The Wealthy, which is very well adapted to the Baldwin belt, is an exception to this, and grows to perfection in both regions. We have observed the Baldwin for several years in an orchard growing on the higher elevations of the Green Mountains. Here it occasionally matures pretty well. In other years it is small, dull

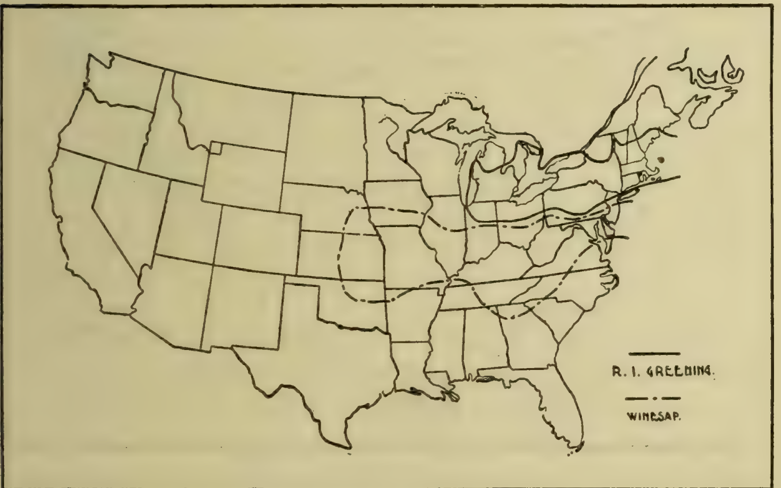

FIG. 11.

green and red in color, and of acid, astringent flavor, indicating that the variety has not had sufficient heat to mature properly. In the Champlain valley, while a standard market apple, it in most seasons fails to reach the size, color and quality that it does in western New York and south central New England. The same applies to its growth in Maine. One may observe in traveling northward through that State increasing signs of immaturity. In Massachusetts 1,000 to 1,200 feet is about the limit of certain full maturity.

Winesap. — The Winesap is a variety that has been known for a long time and has been tested over a wide area. It be-

longs to the south central belt, being grown from southern New Jersey, Virginia and North Carolina west through the Ohio valley to southern Nebraska. It reaches as far south as Georgia on the higher elevations. It reaches the highest favor in the eastern section of this belt, being of secondary importance west of the Allegheny Mountains. When grown in southern New England it is somewhat inferior in size, of doubtful color and flavor, although it keeps better than when grown in many places in its native region. It has found very little favor north of Pennsylvania and New Jersey. Specimens from Arkansas

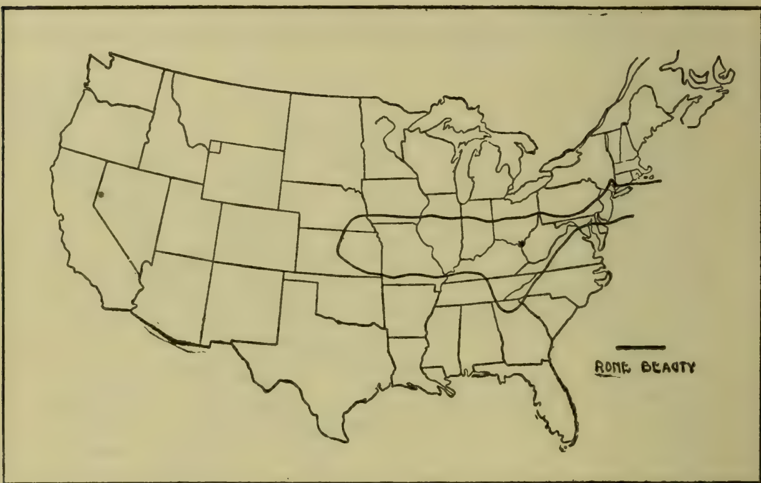

FIG. 12.

and Alabama were of medium size, though somewhat inferior in color and of only moderately good quality. Summarizing his observations regarding its behavior in Virginia and North Carolina Gould says: —

It is apparent that the conditions in the northern portion of the Piedmont region at 1,000 to 1,200 feet elevation do not produce the best results, and that in the more southern counties of Virginia which have been referred to the conditions produce very excellent fruit, but less satisfactory results are secured at points having elevations which much exceed that of the Piedmont region, while still farther south this variety can be grown at higher altitudes than is possible in the northern portion of the Piedmont. Its behavior thus indicates in an interesting way the

corresponding relationship between altitude and latitude in their influence upon the behavior of this variety.[1]

Rome Beauty. — The Rome Beauty is an apple grown principally in southern Ohio, although it is found quite generally over the entire middle portion of the central belt. It is mentioned as a valuable commercial apple for Maryland, Delaware, southern Ohio, southern Indiana and southern Illinois. Specimens from Arkansas were of poor quality, but were of good size and color.

In Virginia, on Cecil sandy loam, at 900 feet, it is especially satisfactory, particularly in view of the fact that these conditions are unfavorable to most varieties. So grown, it is said to keep until the holidays. Cecil clay and Porters clay at elevations of 1,000 to 1,500 feet, in the northern Piedmont and Blue Ridge regions, usually combine conditions which are favorable to this variety. At 1,500 feet altitude on Porters clay it becomes an early winter variety of very fine appearance and good dessert quality. As a rule, it is considered especially well adapted to sandy soil. On Porters black loam, at 2,300 feet, it is considered of more than usual value. It is highly prized in western North Carolina, where it occurs at an altitude of 3,000 feet, on a deep porous mountain loam. It is, however, somewhat inclined to drop.[2]

York Imperial. — While the York Imperial is believed to have originated fully one hundred years ago, its period of commercial development extends over a much shorter time. It came from southeastern Pennsylvania, and there it has attained its greatest commercial value. It has spread, however, over nearly the whole of the south central belt. It is recommended as a valuable commercial variety in New Jersey, through southern Ohio to southern Iowa and Nebraska. To the south it is much valued as far as North Carolina on the higher elevations and west through Missouri and eastern Kansas. Its distribution is therefore very similar to the Ben Davis, although it has not spread into northern localities as has that variety, nor does it extend quite as far west. As to its behavior in the southern Appalachian Mountains Gould says: —

It appears to be less influenced by soil conditions than by elevation. In the Piedmont orchards having less than 1,000 to 1,200 feet elevation

[1] Bureau of Plant Industry, Bulletin 135, p. 46.
[2] Gould, Bureau of Plant Industry, Bulletin 135, p. 43.

serious rotting and premature dropping are apt to occur, and while frequent exceptions to this have been observed, it is sufficiently constant to suggest that extensive plantings of it in this region should be made cautiously, if at all, except in the northern portion, where it appears to be more nearly free from serious faults than almost any other commercial variety that is being grown, and is considered one of the most profitable sorts. This applies specially to locations in Rappahannock County, in close proximity to the mountains. In the Blue Ridge region above an elevation of 1,200 to 1,500 feet premature dropping is generally less severe than it is at lower points. Especially satisfactory results have usually been obtained on Porters clay at these middle elevations, where very heavy crops are expected, at least in alternate years. If heavy dropping occurs in such cases, a sufficient quantity of fruit

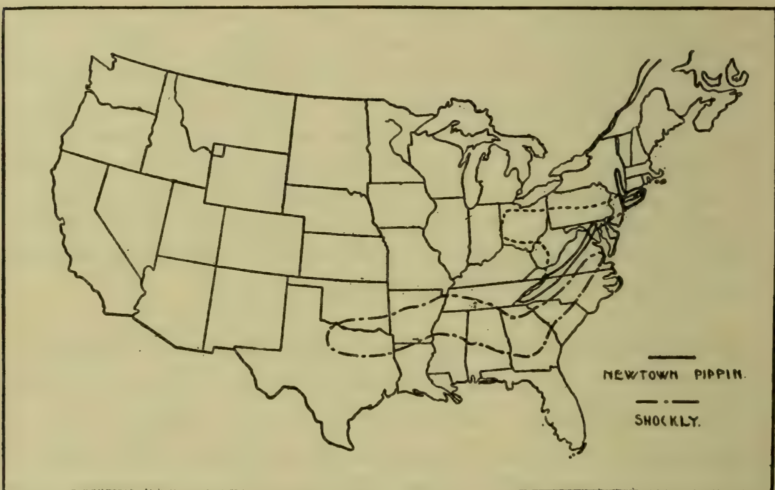

Fig. 13.

usually remains to result in a heavy crop. At the higher altitudes this is considered a valuable variety, especially in North Carolina, where it has grown at 2,500 to 3,500 feet altitude. . . . The contrast between this variety and Winesap in the manner in which they respond to the influence of elevation is of interest. The elevation at which Winesap begins to deteriorate and above which it becomes more inferior as the elevation increases appears to be about the point below which York Imperial is inclined to manifest certain faults which tend to disappear at higher altitudes.[1]

Yellow Newtown. — This variety is one of restricted cultivation. The only region in the east where it can be said to have

[1] Bureau of Plant Industry, Bulletin 135, p. 49.

commercial standing is in the Hudson Valley and Long Island, and in the Upper Piedmont and Blue Ridge sections of Virginia and North Carolina. It has also attained favor in certain sections of the Pacific northwest. It is therefore an apple of the central belt. The climatic conditions, particularly the mean summer temperature, of the several regions where this variety is cultivated are even more alike than is indicated by the temperature map. The tree makes a slow growth and is rather late in coming into bearing. The variety requires better care than do many of the leading commercial sorts. The tree is evidently unable to withstand the conditions of the western plains, and apparently does not succeed west of Indiana. We are confident, however, that if given good care it will do well in many places in Pennsylvania and central Ohio, provided, also, that the soil conditions are right. Gould devotes considerable space to a discussion of the behavior of this variety in the southern Appalachians, mostly with reference to its soil preferences. He concludes that it requires a soil or high fertility and of a loose, friable texture; and a subsoil comparatively open and porous. Bearing on climatic conditions he says: —

> This apple is found principally in the mountains, at various altitudes and in coves where Porters black loam abounds, often at elevations not exceeding the general level of the Piedmont. Even these lower points, where the drainage is good, are favorable places for this variety, though the higher altitudes are to be preferred.[1]

In Nelson County, Va., the slopes of the mountains and hills at elevations of 1,000 to 1,500 feet are considered desirable locations. In northeastern Georgia premature dropping was observed. In Fig. 13 the solid line shows where the variety is generally recommended, and the dotted line includes additional territory where we believe it would do well in favorable locations and with good care.

Ben Davis. — This variety has been quite fully dealt with in a previous publication.[2] We have little to add to the statements made at that time. Many other samples of the variety have

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[1] Bureau of Plant Industry, Bulletin 135, p. 48.

[1] Massachusetts Experiment Station Report, 1910, p. 197.

been studied and additional data as to variation in form and size have been secured, and these are set forth in an earlier portion of this paper. It cannot be grown to its full development north of southern Pennsylvania, central Ohio and Indiana, north central Illinois and central Iowa, although it is often a profitable commercial variety further north than this. It is, however, inferior in most respects to the variety grown south of that line. It is apt to be hard and astringent and poorly colored, and undersized unless grown under relatively high cultural conditions. The map given in Fig. 14 shows the

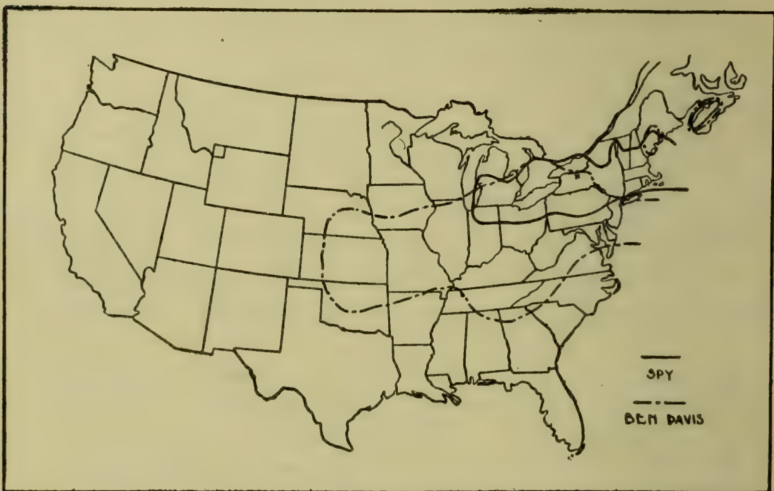


Fig. 14.

distribution of this variety. This shows it extending farther north than the map given in a previous report. It should be borne in mind that the previous map shows the area over which it is the leading commercial variety and the present map the area where it may be said to rank as a valuable commercial sort.

Shockley. — Shockley is a variety belonging almost exclusively to the southern belt. It flourishes in regions where the summer heat is greater than that favorable to most commercial varieties. It is recommended for cultivation in the hill and pine belt regions of South Carolina, and west through northern and central Alabama to northeastern Texas. Gould gives the

following concerning its behavior in the southern Appalachian Mountains: —

At 1,500 feet altitude in Albemarle County, Va., on Porters clay, this variety is not considered of special value, but at the same elevation in Georgia on a soil containing rather more sand than Porters clay does, with good culture it comes to a high degree of perfection, and when held until midwinter it generally brings very satisfactory prices in local markets. In the southwestern part of North Carolina, at 1,700 feet elevation, on a friable, porous loam, with good culture it bears annual crops of highly colored fruits, which develop to a larger size than under most conditions. In North Carolina at 3,500 to 3,800 feet, while the Shockley bears heavily and colors well, it is usually too small to be of much value, especially as other more desirable sorts succeed at these elevations. The clay and clay loam soils of the Piedmont region, with the usual elevations of those soils, may be expected, as a rule, to produce this variety in a fair degree of perfection.[1]

The Relation of Temperature to Development.

The Mean Summer Temperature. — There is a close relation between the mean summer temperature and the development of the fruit. For every variety there can be determined a mean summer temperature at which it reaches its highest and most satisfactory development. Any departure from this mean results in greater or less inferiority of the fruit, the degree of inferiority depending on the amount of the departure, and the variety. For the successful growth of the tree the mean summer temperature is of little significance, but the major controlling factors are the minimum winter temperature and the mean of the hottest part of the summer. Other factors enter in, but we believe that these are the principal ones and must first be complied with if a variety is to succeed.

The Winter Minimum. — The temperature which a tree of a given variety can withstand cannot be stated with definiteness. It depends not only on the degree of cold, but also on the condition of the tree and the rapidity and amount of the fall and subsequent rise of the temperature. In the northwestern belt this is the great problem of apple culture, and much study has been given to it. The Minnesota Horticultural Society men-

[1] Bureau of Plant Industry, Bulletin 135, p. 43.

tions the following varieties as of sufficient hardiness to endure the severe winters of that State:[1] —

Of the first degree of hardiness, Oldenburg, Hibernal, Charlamoff, Patten, Okabena.

Of the second degree of hardiness, Wealthy, Tetofski, Malinda, Peerless, Northwestern Greening.

Many other sorts thrive in the more favorable parts of this belt, but the great bulk of the varieties grown in localities of similar summer temperatures in the east perish from winter-killing. The minimum winter temperatures in this territory, according to the records of the Weather Bureau,[2] are around —40° F., which may be considered a degree of cold which any tree of *Pyrus malus* can rarely endure without injury (see Fig. 15). It should be borne in mind that this temperature must be taken in accordance with the methods of the Weather Bureau and with correct instruments, else the figures obtained are likely not to be comparable.

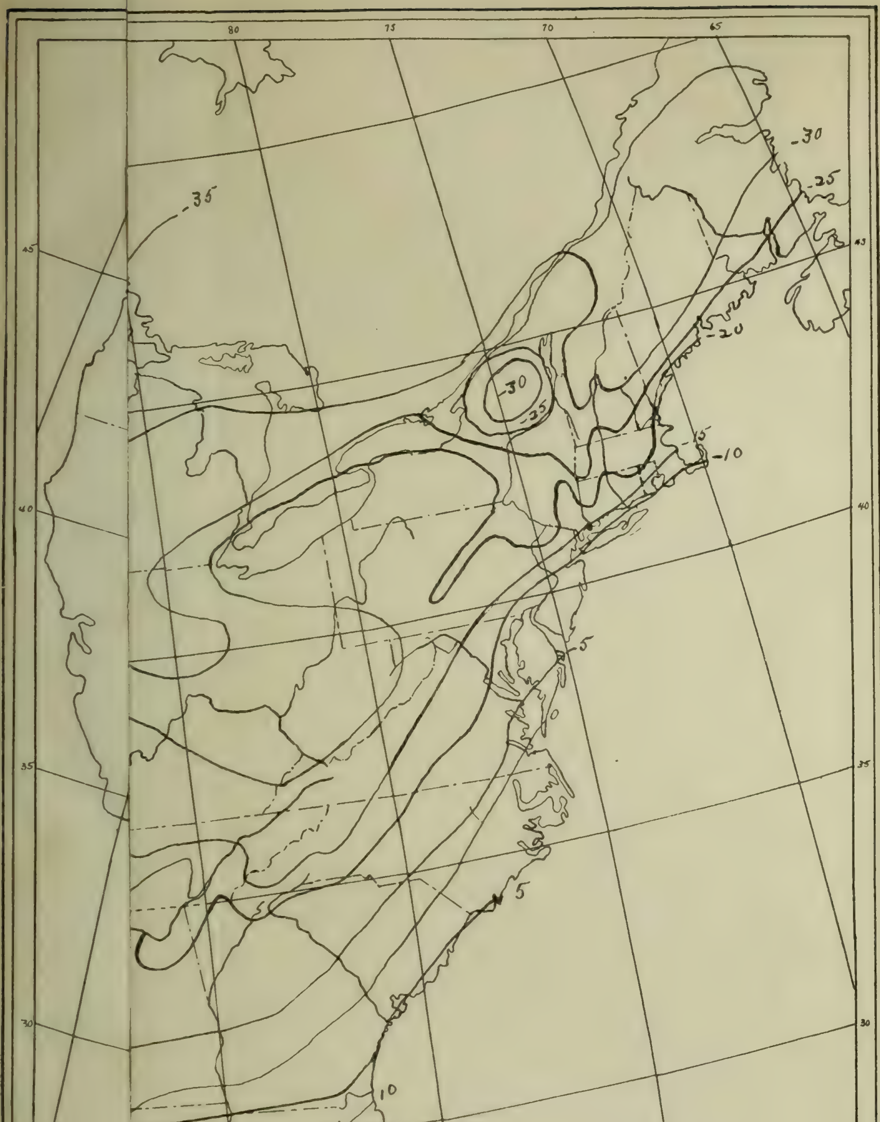
The Heat of Summer.— A glance at the figures (Figs. 6–14) giving the distribution of varieties shows that some extend the entire length of its belt, while others succeed well only through the eastern portion. There are three differences between the eastern and western portions of these belts. In the west we find (1) lower humidity, (2) less precipitation, (3) more severe heat during the summer. Probably all these have their influence in limiting the western spread of certain varieties, for their effects on the plant are similar, in that they tend to dry it out. In relative importance the greater heat is probably of the greatest significance followed by rainfall and humidity.

The Effects of Low and High Mean Summer Temperatures. — The effects on the fruit of a low summer heat, as indicated by the mean summer temperature, are as follows: —

1. Greater Acidity. — It is shown that the acidity of the fruit steadily decreases all through the stages of growth, ripening and decay. It naturally follows that if the fruit does not have time to mature properly it will be acid, and this is clearly shown in the table of analyses.

[1] Report, 1907, p. 34.

[2] United States Weather Bureau, Bulletin Q.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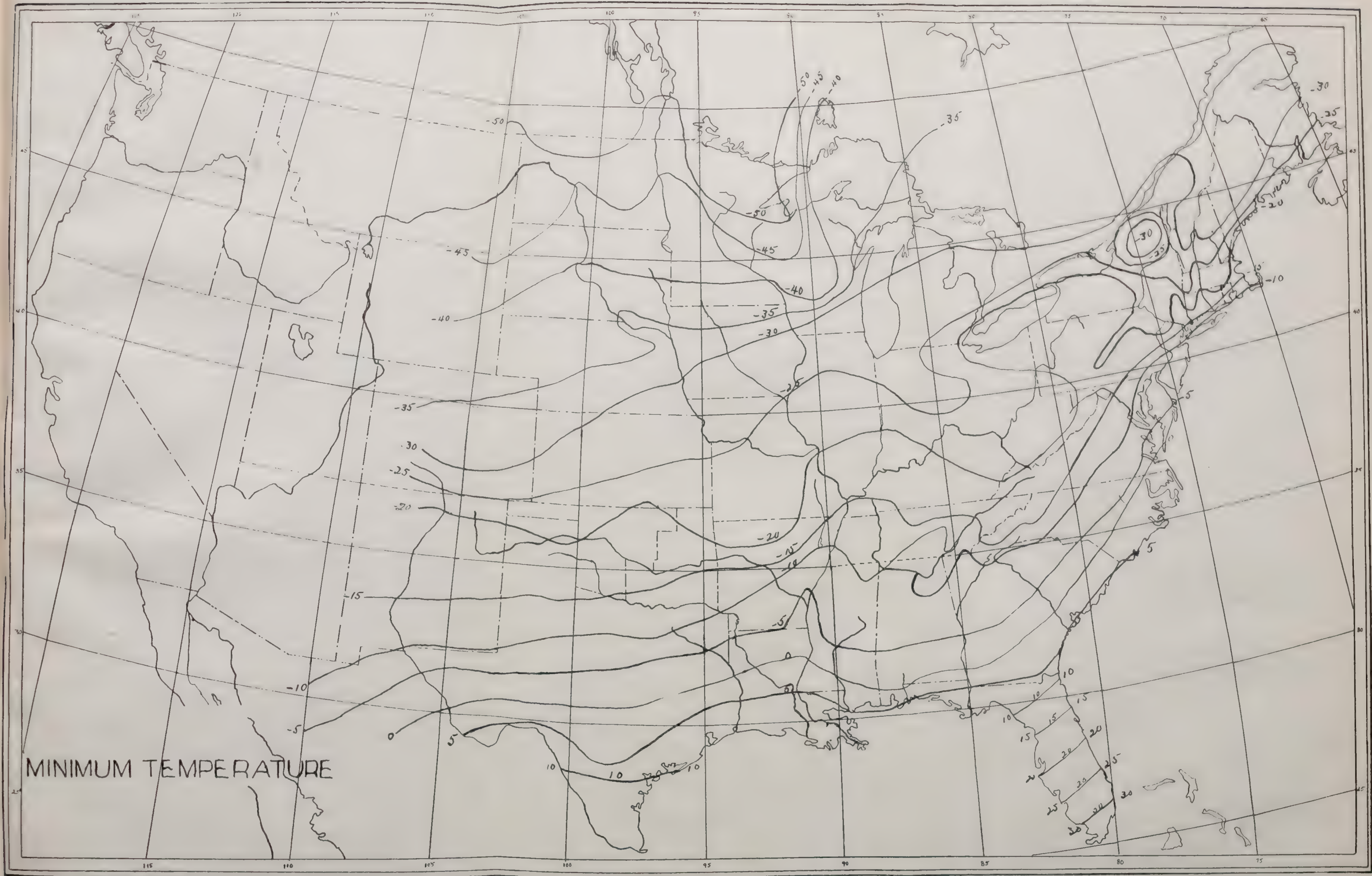
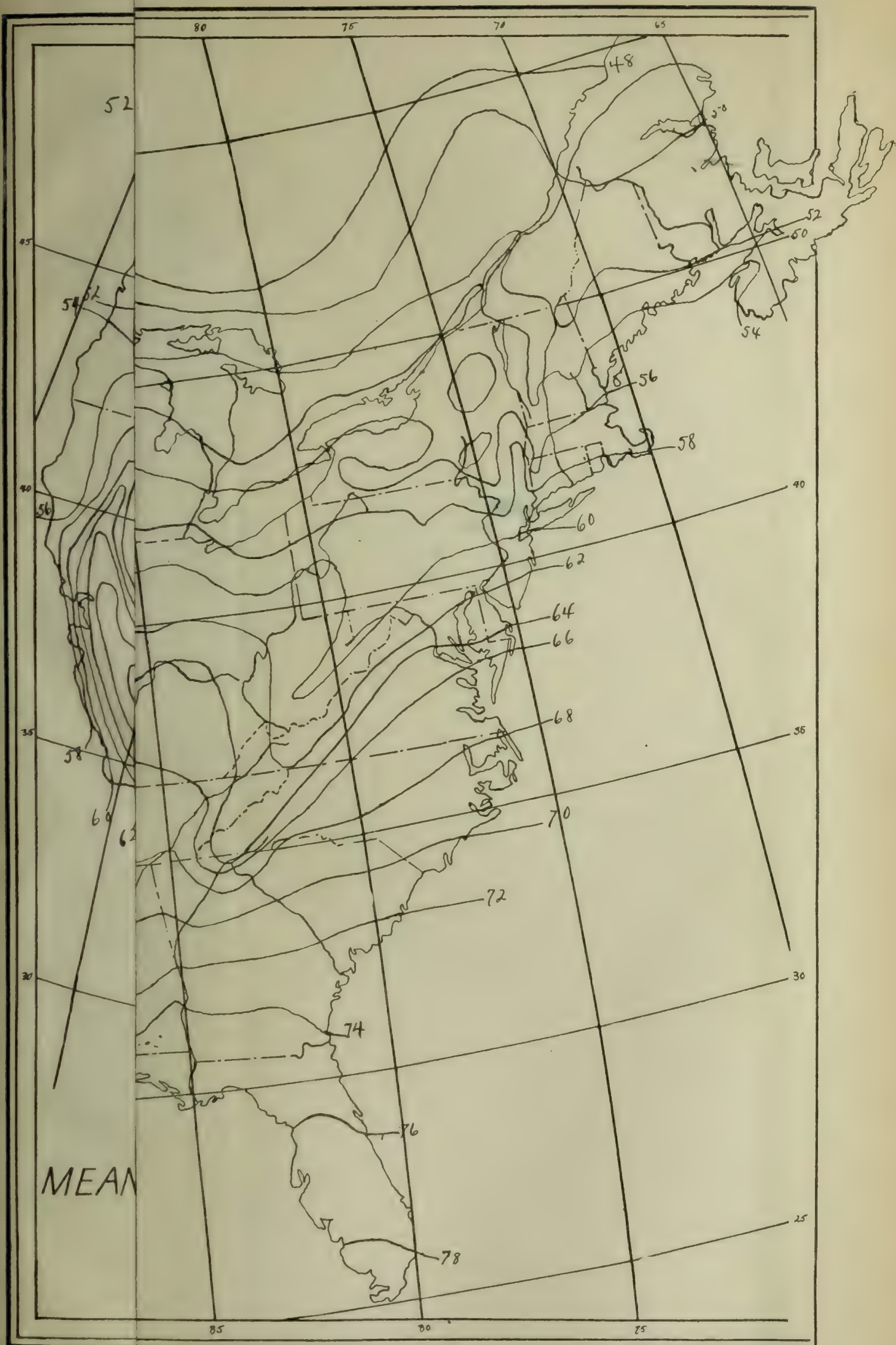


FIG. 15.—ISOTHERMS OF MINIMUM WINTER TEMPERATURE.



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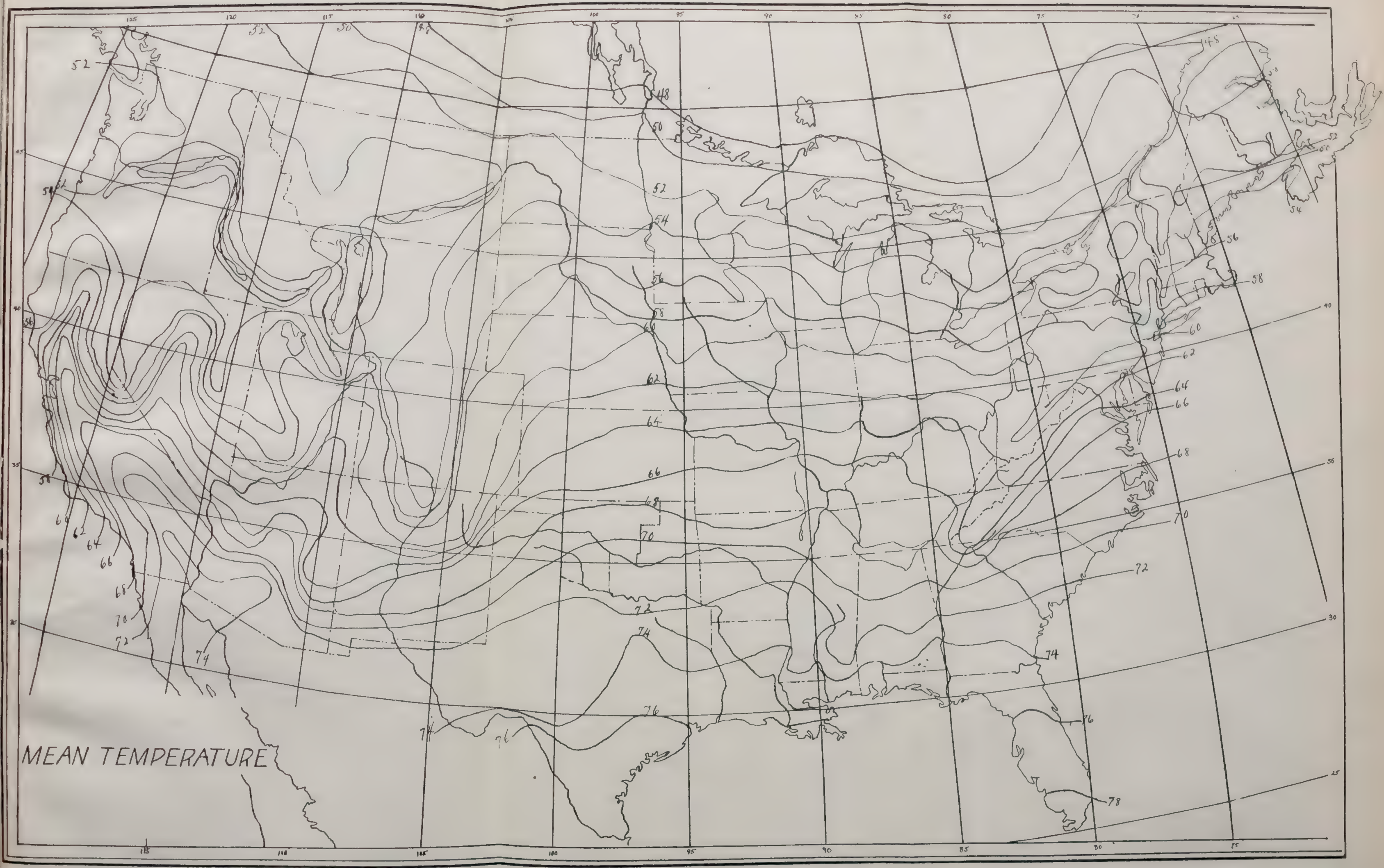

FIG. 16.—ISOTHERMS OF MEAN SUMMER TEMPERATURE.

2. *A Higher Content of Insoluble Solids.* — The analyses show that there is a decided tendency for the insoluble solids to decrease during the stage after ripening. The figures do not show just when the content of insoluble solids is highest, but it must be at or before the time of picking. The analyses also give clear indication of the immaturity of the fruit when grown too far north. This is especially marked in the case of the Ben Davis, doubtless owing to the fact that some lots of this variety came from the far north of the region in which it matures properly, and it falls far short of full maturity. It shows an average content of 2.97 per cent. for the Ben Davis belt and 3.60 per cent. for the specimens from north of this region. Other sorts show similar differences.

3. *Greater Astringency.* — All apples in an immature state doubtless contain small amounts of tannin. No determinations of tannin have been made in connection with this work, nor have we discovered any report that shows conclusively just what changes in tannin content go on in the growing and ripening fruit. Nevertheless, it is evident to the taste that green apples have greater astringency than do ripe specimens, and we have repeatedly observed a markedly greater astringency in northern-grown apples than in the same sort grown farther south.

4. *Less Coloration.* — It is well known that plants exhibit brighter, more intense coloration when grown in high latitudes and altitudes. This is true of the coloration of red apples. In the north we find bright intense reds, which become duller towards the south, with a tendency toward a pinkish red towards the southern limit. The proportion of the fruit covered, however, behaves in a different way. We find the greatest proportion of color near the middle of a distribution, with a decrease to both the north and south. We find then, near the center of a distribution of most varieties of red apples, fruit well covered with fairly bright color, which is brighter and more intense in northern varieties than in those of the south.

5. *Decreased Size.* — When the season is short or cool it is natural that a variety should not reach the maximum size. It is somewhat difficult to determine, in lots of varying size, how much of the difference is due to climatic causes and how much

to cultural methods and conditions. However, in the case of the Ben Davis a study of the table on page 199 shows clearly not only the general influence of the different regions on size, but also that of different seasons, and almost invariably a lower summer mean is accompanied by decreased size.

6. *Scalding in Storage.* — It has been shown by Powell [1] and Beach [2] that immature apples are more likely to scald in storage than are those that have been well matured on the trees. In order to keep longest in storage an apple should have fully completed the stages of growth and ripening on the tree, and been picked and without delay placed and kept in a temperature barely above the freezing point of the fruit. In practice it is necessary to allow a margin for safety, owing to possible lack of uniformity of the temperature at different times and in different parts of the storage rooms, but the better the control of the temperature the closer may the ideal conditions be approached. It is probable that scalding may also appear on fruit that has been poorly grown, but still has reached full maturity. The chemical work here reported indicates that fruit matured on poor soil or under unfavorable cultural conditions may be in some respects similar to immature fruit. The poorly grown fruit is lower in most of the soluble solids.

When a variety is grown where the summer mean temperature is excessively high we note the following effects: —

1. *Uneven Ripening.* — Summer and fall varieties always show a tendency to ripen unevenly, making it desirable to make two or more pickings as the different specimens reach maturity. Late fall and winter sorts show less evidence of this, though a difference in the maturity of specimens in a lot of winter fruit may be detected without difficulty. Inasmuch as the result of growing a variety south of its natural range is to cause earlier maturity, and fall varieties tend to become summer varieties, it is to be expected that the uneven ripening characteristic of summer sorts should follow. This is not marked with winter varieties unless they are grown a considerable distance south of their most favorable localities.

[1] Bureau of Plant Industry, Bulletin 48.

[2] New York Experiment Station, Bulletin 248; Iowa Experiment Station, Bulletin 108.

2. Premature Dropping. — It is but natural that dropping of ripened fruit should follow uneven ripening, and this is commonly observed to be the case. We find, also, that apples may drop even at immature stages when the summer heat is too great for the liking of the variety, particularly when the heated period closely follows the period of blossoming.

3. Rotting on the Tree. — This is another sign of summer heat too great for the variety, which is right along the line of those already mentioned. It occurs with most varieties only when the heat is excessive. The Jonathan is especially subject to this trouble, because the margin between temperature that will give the maximum size, color and quality and one that will cause rotting seems to be narrow, and perhaps within the range of seasonal fluctuations. Therefore there is great danger that the apples will become overripe and decay before being picked.

4. Poor Keeping Quality. — This defect of southern-grown specimens is also along the same lines of those already dealt with. The apples mature to the end of the ripening or after-ripening stages, and being still subject to high temperature, continue rapidly on the road to decay. It is probable that in many cases this difficulty might be largely overcome by picking the apples at the proper stage and placing them at once in cold storage. I am informed by Mr. W. A. Taylor of the Department of Agriculture that Baldwins grown in West Virginia kept in a satisfactory manner when handled in this way. The chemical work here reported shows no material difference in the chemico-physiological processes of the growth and maturing of the fruit of a given variety, whether grown in the north or in the south, but only in the degree of completeness with which they are achieved.

The converse of this proposition is that northern-grown fruit, if well matured, will keep better than that variety grown farther south, and this indicates that any variety should be grown as far north as possible to fully mature it in the coolest seasons that are likely to occur. The progress of the stage of after ripening may be easily controlled if the proper facilities are at hand, but it is an advantage to have the air temperature low at this time unless it is desired to hasten instead of retard this stage.

5. *Lack of Flavor.* — The basis of flavor in apples has already been discussed. The leading element of flavor for discussion here is that of the flavoring oils. It appears that for high development of these a relatively cool atmosphere is desirable. Summer and early fall varieties do not, as a rule, possess high flavors, and any late fall or winter variety grown so far south that it ripens before the cool weather of autumn comes is likely to be inferior in the development of flavoring oils.

6. *"Mealiness."* — This is another sign of overripeness that is an indication that the variety is grown in too great summer heat. Mention has already been made of the softening of the middle lamellæ, which is the cause of this mealiness (see page 186). The result is that when eaten the cells separate from each other without breaking open and releasing the juices contained therein, and the apple is said to be "dry," whereas it probably contains a normal amount of water. Some varieties, the Jonathan, for example, do not show this characteristic in marked degree, but most varieties do if they can be kept long enough without parasitic decay, and the warmer they are the shorter the time necessary to bring about this result.

7. *Less Intense Color.* — A red variety grown to the south of its normal range is apt to show a less intense color, though it may be pretty well spread over the fruit. There is often a decided tendency toward a pinkish red, which may appear pale or faded in extreme cases.

Bright sunlight during the ripening period of the fruit has much to do with the attainment of high color, especially if at this time the nights are cool and frosty. But in order for these influences to have their full effect the apple must have been brought to the proper stage of development by a sufficient amount of heat during the period of growth. Underdeveloped apples do not take on a satisfactory color, no matter how favorable the conditions may be during the ripening period.

8. *Smaller Size.* — This effect does not manifest itself unless the variety is grown far to the south of its most favorable region. The signs of overripeness show themselves much sooner as one goes south over the distribution of a variety. Nevertheless, in some cases, at least, it is evident that a variety may fail

to reach its normal size on account of too severe summer heat. It is probable that this occurs most noticeably in the extreme south of the apple region. We have seen evidences of it in the Ben Davis and Winesap that were grown about as far south as these varieties are much cultivated.

The Optimum Mean Summer Temperature. — It is evident from the foregoing discussion that the development of the highest perfection in any given variety is closely related to most favorable mean summer temperatures. In Table 5 is given a list of varieties, with an estimate of the optimum temperature for each sort, and in some cases of their possible range and hardiness with respect to the cold of winter. The list of varieties includes all those that are given the double star, indicating highly successful varieties, in the list of the American Pomological Society, with a number of additions of varieties that, for various reasons, seemed worthy of consideration. Inasmuch as we consider keeping quality of considerable account with most sorts, the policy has been to prescribe about as low a temperature as will suffice to thoroughly mature a variety, leaving a margin of about 2° for seasonal fluctuations; that is, we believe that any variety may be matured when the summer mean is 2° lower than the one given. This applies more particularly to the fall and winter varieties. We believe, on the other hand, that any increase in the summer mean for any variety, unless it be the earliest ones, will be a disadvantage, though a very slight one, if the rise is not more than 1° or 2°. Up to a certain degree the overmaturity of the fruit in a too warm climate may be overcome if the grower will pick at the time of full maturity and put the fruit at once in cold storage. If the heat is too great, however, even with this method the fruit will be inferior in flavor and color, and, in very extreme cases, in size. We believe that a departure of more than 2° in either direction from the temperatures given will be a noticeable disadvantage with any of the winter varieties. This remark will apply less to the fall sorts and still less to the summer varieties; or, to put it in other words, the earlier the variety the greater may be its range of temperature without marked deterioration of the fruit. There are doubtless errors in the case of some varieties, concerning which we have limited infor-

mation. It is hoped that these may, in time, be corrected, as we are able to learn more concerning the behavior of these varieties under different conditions.

In Table 6 these same varieties are grouped under their optimum temperatures for convenience in reference.

In Table 5 there is also given for some varieties the range of temperature which they can stand without serious deterioration. This is, as already stated, closely connected with the season of the variety, being wide with early sorts and relatively narrow with most winter sorts. Just how much difference there is between the ranges of varieties of the same season is difficult to say. It is complicated with a variety of related questions.

In the case of a few of the varieties given in Table 5 an attempt is made to give their hardiness with respect to the winter cold. Inasmuch as the ability of the tree to withstand cold depends on a variety of factors other than the temperature, it is of no use to attempt to state this in degrees. The designation Ex. H. is used for the varieties equal in hardiness to those classified as of the first degree of hardiness; the designation V. H. for those of the second degree of hardiness (by the Minnesota Horticultural Society); and the designation H., M. and T. for various degrees of hardiness below these two classes. Many of the more southern sorts are not grown far enough north on account of a lack of summer heat to test their winter hardiness in a satisfactory manner. Therefore it is impossible to make any statements regarding them, nor would there be any practical value in such statements were they possible.

TABLE 5. — *Mean Summer Temperatures.*

	Optimum Temperature (Degrees).	Range.	Hardiness.		Optimum Temperature (Degrees).	Range.	Hardiness.
Akin,	52			Holland Winter,	57		
Alexander,	54		H.	Horse,	66		
Arctic,	53		H.	Hubbardston,	57		
Arkansas,	65			Huntsman,	62	N.	N.
Arkansas Black,	63			Hyde King,	60		
Babbit,	57			Ingraham,	62		
Bailey Sweet,	58						
Baldwin,	56	N.	M.	Jefferis,	57		
Baxter,	53		H.	Jewett,	54		
Beach,	65			Jonathan,	59	N.	N.
Ben Davis,	64	M.	H.	July,	59		
Benoni,	59						
Bethel,	53		H.	Kent Beauty,	58		
Bietigheimer,	53			Keswick,	58		
Bismark,	53			King David,	59		
Black Gilliflower,	55			Kinnaird,	59		
Blenheim,	55						
Blue Pearmain,	54		H.	Lady,	58		
Boiken,	57			Lady Sweet,	57		
Bonum,	65			Lankford,	61		
Borovinka,	53			Lawver,	64		
Bough,	57			Limbertwig,	66		
Buckingham,	66			Longfield,	57		
Buncombe,	66			Lowell,	58		
				Lowland Raspberry,	58		
Cabashea,	58						
Cannon Pearmain,	65			Maiden Blush,	61	M.	V. H.
Charlamoff,	53		Ex. H.	Malinda,	54	N.	H.
Chenango,	57			Mann,	55	M.	
Collins,	65			McAffee,	60		H.
Cooper Market,	60			McIntosh,	56	W.	H.
Cox Orange,	35			McMahon,	55		
				Melon,	57		
Delicious,	59			Milden,	58		H.
Dominie,	60			Milwaukee,	54		H.
Dudley,	53			Minkler,	60		
				Missouri Pippin,	64		
Early Harvest,	56	V. W.		Monmouth,	57		
Early Joe,	56			Mother,	58		
Early Pennock,	56						
Early Strawberry,	58			Newell,	55		
English Russet,	56			Newtown Spitzenburg,	60		
Esopus,	59	N.		Northern Spy,	56	M.	H.
Ewalt,	58			Northwestern Greening,	55		V. H.
Fallawater,	60			Okabena,	52		Ex. H.
Fall Harvey,	57			Oldenburg,	52	V. W.	Ex. H.
Fall Orange,	57			Oliver,	64		
Fall Pippin,	58			Ontario,	56		H.
Fameuse,	54	M.	H.	Ortley,	61		
Fanny,	63						
Flushing Spitzenburg,	58			Paragon,	64		
Foundling,	54		H.	Patten,	55		Ex. H.
				Payne,	62		
Gano,	64	M.		Peck Pleasant,	58		
Gideon,	51		H.	Peerless,	56		V. H.
Golden Russet,	56			Pewaukee,	53		V. H.
Golden Sweet,	58			Plumb Cider,	57		
Gravenstein,	55	M.	M.	Pomme Gris,	55	N.	
Green Sweet,	58			Porter,	57	W.	
Grimes,	62	M.	H.	Primate,	57		
				Pumpkin Sweet,	57		
Haas,	59		H.				
Hagloe,	60			Ralls,	62		
Hibernal,	52	N.	Ex. H.	Rambo,	60		
Holland Pippin,	57			Red Astrachan,	54	W.	H.

TABLE 5. — *Mean Summer Temperatures* — Concluded.

	Optimum Temperature (Degrees).	Range.	Hardiness.		Optimum Temperature (Degrees).	Range.	Hardiness.
Red Canada,	59	M.		Tolman,	56	M.	H.
Red June,	58	M.		Tompkins King,	56	M.	M.
Rhode Island Greening,	56	M.	H.	Twenty Ounce,	58		M.
Ribston,	55	N.		Twenty Ounce Pippin,	58		
Rolfe,	56		H.				
Roman Stem,	61			Wagener,	59		
Rome Beauty,	60			Walbridge,	54		H.
Roxbury Russet,	57	W.	H.	Washington Royal,	56		
				Wealthy,	56	W.	V. H.
Salome,	55		H.	Westfield,	56		
Scott Winter,	55		V. H.	White Astrachan,	54		
Shiawasse,	55		H.	White Pearmain,	62		
Shockley,	65	N.		White Pippin,	61		
Smith Cider,	61			Williams,	57	W.	
Smokehouse,	60			Willow,	64		
Stark,	62	M.	H.	Windsor,	55		H.
Stayman Winesap,	63			Winesap,	64	M.	
St. Lawrence,	54			Winter Banana,	58		
Sutton,	56			Wolf River,	54	M.	V. H.
Swarr,	58						
Swazie,	55	N.		Yates,	67		
Switzer,	58			Yellow Belleflower,	61	W.	
				Yellow Newtown,	60	V. N.	
Terry,	67	N.		Yellow Transparent,	53	W.	V. H.
Tetofski,	53	V. W.	V. H.	York Imperial,	62	M.	
Titovka,	56		H.				

TABLE 6. — *Optimum Temperatures by Groups.*

52°.	53°.	54°.	55°.
Hibernal	Arctic	Alexander	Black Gilliflower
Okabena	Baxter	Blue Pearmain	Blenheim
Oldenburg	Bethel	Fameuse	Cox Orange
	Bietigheimer	Foundling	Gravenstein
	Bismark	Gideon	Mann
	Borovinka	Jewett	McMahon
	Charlamoff	Malinda	Newell
	Dudley	Milwaukee	Northwestern Greening
	Pewaukee	Red Astrachan	Patten
	Tetofski	St. Lawrence	Pomme Gris
	Yellow Transparent	Walbridge	Ribston
		White Astrachan	Salome
		Wolf River	Scott Winter
			Shiawasse
			Swazie
			Windsor

56°.	57°.	58°.	59°.
Baldwin	Babbit	Bailey Sweet	Benoni
Early Harvest	Boiken	Cabashea	Delicious
Early Pennock	Bough	Early Joe	Esopus
English Russet	Chenango	Early Strawberry	Haas
Golden Russet	Fall Harvey	Ewalt	Jonathan
Lowland Raspberry	Fall Orange	Fall Pippin	July
McIntosh	Holland Pippin	Flushing Spitzenburg	King David
Milden	Holland Winter	Golden Sweet	Kinnaird
Northern Spy	Hubbardston	Green Sweet	Red Canada
Ontario	Jefferis	Kent Beauty	Wagner
Peerless	Lady Sweet	Keswick	
Rhode Island Greening	Longfield	Lady	
Rolfe	Melon	Lowell	
Sutton	Monmouth	Mother	
Titovka	Plumb Cider	Peck Pleasant	
Tolman	Porter	Red June	
Tompkins King	Primate	Swarr	
Washington Royal	Roxbury Russet	Switzer	
Wealthy	Williams	Twenty Ounce	
Westfield		Twenty Ounce Pippin	
		Winter Banana	

60°.	61°.	62°.	63°.
Cooper Market	Lankford	Akin	Arkansas Black
Dominie	Maiden Blush	Grimes	Fanny
Fallawater	Ortley	Huntsman	Stayman Winesap
Hagloe	Roman Stem	Ingram	
Hyde King	Smith Cider	Payne	
McAffee	White Pippin	Ralls	
Minkler	Yellow Bellflower	Stark	
Newtown Spitzenburg		White Pearmain	
Rambo		York Imperial	
Rome Beauty			
Smokehouse			
Yellow Newtown			

64°.	65°.	66°.	67°.
Ben Davis	Arkansas	Buckingham	Terry
Gano	Beach	Buncombe	Yates
Lawver	Bonum	Horse	
Missouri Pippin	Cannon Pearmain	Limbertwig	
Oliver	Collins	Shockley	
Paragon			
Willowtwig			
Winesap			

Chemical Determinations.

The work here reported is based in considerable degree on chemical work done in the laboratory of the college. During the past two years over 150 samples of apples have been subjected to partial analysis, the results of which, so far as they are deemed worthy of publication, are presented in Table 7. The names and locations of the growers are as follows: —

Name.	Post-office Address.	Name.	Post-office Address.
F. Bovyer, . . .	Charlottetown, P.E.I.	Slaymaker & Son, .	Wyoming, Del.
C. E. Hardy, . .	Hollis, N. H.	Dr. S. S. Guerrant, .	Callaway, Va.
Edw. Lefavour, . .	Marblehead, Mass.	G. C. Sheible, . .	Tiptop, Ky.
Massachusetts Agricultural College, . .	Amherst, Mass	G. H. & S. G. Ellis, .	Dayton, Tenn.
J. M. Fisk, . . .	Abbottsford, Que.	J. O. Kelley & Sons, .	Jeff, Ala.
T. L. Kinney, . .	South Hero, Vt.	Joe H. Burton, . .	Mitchell, Ind.
G. H. Wright, . .	Middlebury, Vt.	J. C. B. Heaton, .	New Burnside, Ill.
Wilfred Wheeler, .	Concord, Mass.	Geo. T. Lincoln, .	Bentonville, Ark.
F. S. Wallbridge, .	Belleville, Ont.	Geo. L. Sipes, . .	West Fork, Ark.
Connecticut Agricultural College, .	Storrs, Conn.	C. S. Bouton, . .	Springfield, Ark.
New York Experiment Station, . . .	Geneva, N. Y.	G. S. Christy, . .	Lincoln, Neb.
Wm. Miller, . .	Gypsum, O.	Kansas State Agricultural College, .	Manhattan, Kan.
U. T. Cox, . . .	Proctorville, O.	Ira Townsend, . .	Iola, Kan.
Wm. Stewart, . .	Landisburg, Pa.	J. B. Fergus, . .	Kincaid, Kan.
F. H. Fasset, . .	Meshoppen, Pa.	G. B. Prince, . .	Santa Fé, N. M.
S. H. Derby, . .	Woodside, Del.	E. F. Cadwallader, .	Mountain Park, N. M.
A. J. Norman, . .	Harris' Wharf, Md.	Stirling & Pitcairn, .	Kelowna, B. C.

As a rule the samples represent about the best type of the various varieties grown in the different localities. The samples received varied from a half dozen to a barrel, and from these from six to twelve good specimens were selected for analysis. They were ground in a food chopper, and after weighing a sample for sugar determinations, were preserved in a glass jar with formaldehyde. The methods of analysis followed were those of Bulletins 66 and 107 of the Bureau of Chemistry.

The determination of total solids was made by drying 25 grams on pumice in a water oven at 95° to 98° for twenty

to twenty-two hours. This probably gives results too low, but this method seemed the best with the facilities at hand. Insoluble solids were determined by washing 25 grams with 500 cubic centimeters hot water on muslin filters, and drying on pumice fourteen hours at 95° to 98°. The reducing sugars were determined by reducing Fehling's solution and weighing the precipitate as cuprous oxide; the sucrose, by means of the polariscope; and malic acid, by titrating with N/10 alkali with phenolphthalein as an indicator.

Most of the analyses were made during the winter of 1910-11. All samples, save those from Amherst, were shipped direct to cold storage in Holyoke, Mass., and transferred to Amherst a few samples at a time, as needed, where they were held as cool as possible. The Amherst samples, as well as all those of 1910, were kept in an excellent cellar storage at the college. The laboratory numbers were given in order of analysis, work being begun with No. 1 in November, 1910, and completed about March 1, 1911. The samples of 1910 were analyzed in March, and while no notes of their condition were taken, it can be said that they were in excellent condition, most of them eating ripe.

These analyses form the basis for the chemical side of the discussions of the different varieties in this paper. There are, however, certain questions not dealt with elsewhere which may receive consideration at this point.

Nearly all the differences in analyses between the different samples, aside from those fairly attributable to the unavoidable errors of sampling and analysis, can be traced to one of two causes: (1) varietal differences; these are brought out in Table 1; (2) those attributable to different stages of maturity of the fruit. The chemical changes occurring in the growth and ripening of the apple are clearly brought out in the work of the Bureau of Chemistry, reported in Bulletin 94 of the Bureau, and the reader is referred to that publication for a discussion of this question. During the past winter analyses were made of four samples in November and again in February. These were: —

	November.	February.		November.	February.
Greening, . .	No. 4	No. 93	Baldwin, . .	No. 2	No. 97
Baldwin, . .	No. 1	No. 98	McIntosh, . .	No. 27	No. 102

Reference to the analyses of these samples will show that they are in entire accordance with the results reported in the above-mentioned publication. A study of the figures given shows that, as a rule, varieties grown to the north of their natural range exhibit the characteristics of immature fruits. The analysis of the Ben Davis, sample 91, indicates an apple that failed to mature on the tree, and has gone down in storage after the manner of immature fruit. In general, the analysis of this variety shows that the more northern-grown specimens are low in solids and sugars and high in insoluble solids and acid, and the same is generally true of the other varieties.

TABLE 7. — *Chemical Determinations.*

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
Wealthy.											
Charlottetown, P. E. I.,	19	14.97	1.74	13.23	8.81	1.78	10.59	.60	75×60	40 to 60 per cent. striped and splashed; some blush on sunny side.	Rather poor; lacks Wealthy flavor; very slightly astringent.
Amherst, Mass.,	28	13.38	2.20	11.18	6.91	1.98	8.89	.44	Medium and below	Fair.	Ripe, or a little past; flavoring oils deficient; slightly mealy.
Storrs, Conn.,	6	12.97	2.29	10.68	6.47	1.36	7.83	.46	65×52	Fair; well covered, but not intense.	Rather flat; lacks flavor; may be overripe.
Wolf River.											
Charlottetown, P. E. I.,	16	14.81	3.05	11.76	5.84	6.61	12.45	.72	85×65	Poor to good.	Poor; lacks flavor; astringent; immature and overripe.
Kincaid, Kan.,	72	14.24	2.49	11.75	8.93	.85	9.78	.44	87×66	Pale; poorly covered; pale stripes.	Fair; slightly acid; somewhat mealy.
Mountain Park, N. M.,	14	12.59	2.49	10.10	6.22	3.82	10.04	.74	Medium	Good; nearly blushed; slightly pinkish.	Not equal to those of north; lacks flavoring oils; slight musty flavor.
Maiden Blush.											
Storrs, Conn.,	5	13.23	2.10	11.13	3.95	2.43	6.38	.50	70×53	Good; one-third blushed.	A little flat; perhaps a little overripe; slightly astringent; lacks flavor.
Callaway, Va.,	12	15.39	3.06	12.33	5.05	4.14	9.19	.72	Medium	Greenish; dull red.	Good; better than No. 10; not mealy.
Tip Top, Ky.,	10	15.15	2.83	12.32	5.39	2.85	8.24	.67	Medium	Good; one-third blushed.	Slightly overripe; better than No. 5.
Springdale, Ark.,	11	13.34	2.74	10.60	5.73	1.29	7.02	.35	Medium	Dull; poorer than No. 10.	Overripe; somewhat astringent; mealy; lacks acid.

TABLE 7. — *Chemical Determinations* — Continued.

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
Fameuse.											
Charlottetown, P. E. I.,	13	15.76	2.85	12.91	7.88	.99	8.87	.47	Small	Green; one third dull red.	Fair; rather acid and lacks oils; very thick skin.
Abbotsford, Que.,	44	14.36	2.50	11.86	7.81	1.72	9.53	.19	64×53	Fair to good.	Good.
Storrs, Conn.,	7	14.87	2.32	12.55	6.06	1.64	7.70	.41	68×58	Fair to good; deep dull red.	Fair; somewhat flat; not equal to more northern grown; a little past.
Landisburg, Pa.,	71	15.21	2.33	12.88	9.63	.49	10.12	.23	68×64	Fair; not intense.	Were fair; now overripe; not acid.
Gypsum, O.,	46	15.80	2.79	13.01	8.84	1.34	10.18	.45	Small	Fair.	Good, ripe, or a little past.
Santa Fé, N. M.,	18	14.65	2.75	11.90	8.00	.91	8.91	.43	68×53	Rather pale, blushed and striped.	Fair; lacks Fameuse flavor; not much acid.
McIntosh.											
Charlottetown, P. E. I.,	15	15.40	2.21	13.19	6.80	1.19	7.99	.43	Small; roundish	Green and dull red.	Poor; lacks oils; good texture; slightly astringent.
Abbotsford, Que.,	45	14.26	2.38	11.88	7.09	3.44	10.51	.45	68×60	Very good; deep, rich blush.	Good; ripe; possibly a trifle astringent.
Amherst, Mass.,	27	14.77	2.38	12.39	8.17	2.74	10.91	.38	Medium or above	Fair.	Very good; flavoring oils a little low.
Amherst, Mass.,	102	13.59	2.30	11.29	8.26	1.07	9.33	.31	76×57	Fair.	Much overripe; lacks flavor and body; still juicy.
Geneva, N. Y.,	9	15.05	2.21	12.84	9.90	2.68	12.58	.35	66×54	Striped and blushed; good.	More aromatic and tender than No. 8.
Storrs, Conn.,	8	14.10	2.42	11.68	5.50	2.14	7.64	.39	76×66	Fair to good.	Fair; perhaps a little overripe.
Bitter Root Valley, Mont.,	103	13.30	2.42	10.88	7.41	1.61	9.02	.29	Below medium	Very good.	Not equal to No. 27; seems astringent; perhaps picked immature.
Jonathan.											
Ghent, N. Y.,	105	15.60	2.68	12.92	9.39	.31	9.81	.40	67×56	Fair though not equal to best.	Good; lacks body; barely ripe.
Wyoming, Del.,	49	15.71	2.35	13.36	8.05	2.60	10.65	.42	72×62	Fair.	– –

Proctorville, O.,	24	14.42	2.21	12.21	8.43	1.52	9.95	.42	70×58	Fair; 40 per cent. over color.	Good, but not as rich as No. 23; less mature.
Moran, Kan.,	73	15.88	2.20	13.68	9.88	.00	9.88	.34	68×62	Very good.	Good; prime condition.
Kincaid, Kan.,	80	14.35	2.23	12.12	9.66	.61	10.27	.31	71×58	Fair, not very deep.	Good; fully ripe or a little past.
Tip Top, Ky.,	29	16.18	2.70	13.48	9.00	1.98	10.98	.60	Small	Deep, dull red.	Fair to good.
Mountain Park, N. M.,	23	15.68	2.30	13.38	8.35	3.42	11.77	.55	73×64	Very good; waxy yellow and deep red.	Good; slightly acid; eating ripe.
Hood River, Ore.,	106	13.83	2.23	11.60	8.16	1.34	9.50	.36	73×61	Good, about like No. 105.	Very good; more tender than No. 105; variable.
Ghent, N. Y.,	1910	13.97	2.35	11.62	5.36	2.40	7.76	.39	-	- -	- -
Kelowna, B. C.,	1910	16.24	2.58	13.66	6.48	2.40	8.88	.50	-	- -	- -
Esopus Spitzenburg.											
Cornwall, Conn.,	1910	16.51	2.54	13.97	6.81	3.10	9.91	.49	-	- -	- -
Hood River, Ore.,	1910	19.07	2.79	16.28	7.18	4.22	11.40	.62	-	- -	- -
Grimes.											
Storrs, Conn.,	109	14.97	2.55	12.42	6.71	2.98	9.69	.39	69×64	Good; considerable russet.	Good, but not equal to No. 108; ripe.
Gypsum, O.,	48	18.66	3.04	15.62	5.36	5.43	10.79	.47	67×56	Fair to good; some russet.	- -
Proctorville, O.,	22	17.84	2.52	15.32	8.40	3.34	11.74	.34	71×58	Good; yellow; some russet.	Good, better than No. 21; very slightly acid.
Landisburg, Pa.,	70	14.33	2.24	12.09	7.08	3.50	10.58	.31	75×66	Fair to good; not clear and bright.	Good; more acid and not as rich as No. 68 and No. 69.
Wyoming, Del.,	50	17.58	2.81	14.77	5.81	4.71	10.52	.64	80×65	Good, slightly russeting.	Excellent; prime condition.
Mitchell, Ind.,	68	15.95	2.50	13.45	8.35	4.24	12.59	.24	76×67	Excellent; clear, rich yellow.	Excellent; fully ripe; sweetish.
Tip Top, Ky.,	21	19.87	3.07	16.70	8.35	5.54	13.89	.50	66×54	Good; very slightly russet.	Fair; lacks flavoring oils; slightly overripe.
Moran, Kan.,	69	16.62	2.48	14.14	8.39	3.46	11.85	.28	74×62	Very good.	Good; slightly wilted; a little overripe.
Kelowna, B. C.,	108	15.40	2.42	12.98	6.86	2.98	9.84	.34	71×65	Excellent; clear straw-yellow.	Excellent; crisp; mild subacid; just ripe.
Storrs, Conn.,	1910	16.00	2.84	13.16	6.53	2.97	9.50	.39	-	- -	- -
Kelowna, B. C.,	1910	16.68	2.65	14.03	7.82	3.38	11.20	.29	-	- -	- -

TABLE 7. — *Chemical Determinations* — Continued.

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
King.											
Amherst, Mass.,	26	15.20	2.53	12.67	8.61	2.06	10.67	.35	Medium	Rich, yellow, fair over-color.	Good; ripe, or a little past.
Gypsum, O.,	35	17.75	2.36	15.39	8.25	2.71	10.96	.41	82×72	Good, somewhat russeting.	Very good; clear, mild subacid; somewhat mealy; a little overripe.
Rhode Island Greening.											
Amherst, Mass.,	4	15.29	2.68	12.61	3.91	4.07	8.01	.62	Large	Good, yellow-green.	Good, though not very rich.
Amherst, Mass.,	93	14.23	2.91	11.32	6.04	1.42	7.46	.52	84×65	Good, yellow-green.	Very good; slightly past time.
Gypsum, O.,	53	16.25	3.12	13.13	6.45	3.88	10.33	.75	80×58	Good, greenish.	Very good; not very acid; eating, ripe.
Landisburg, Pa.,	75	17.51	2.86	14.65	7.98	3.71	11.69	.48	80×64	Good, deeper yellow than No. 74.	Good, better than No. 74; richer and sweeter.
Kincaid, Kan.,	74	15.05	2.68	12.37	7.48	1.77	9.25	.38	85×65	Good, clear yellowish-green.	Fair; not up to best; possibly a little overripe.
Northern Spy.											
Port Williams, N. S.,	1910	16.80	2.62	14.18	6.91	3.42	10.33	.43	-	- -	- -
Charlotteville, P. E. I.,	86	14.22	2.98	11.24	8.48	1.42	9.90	.59	72×62	Fair; 20 per cent. striped and splashed.	Poor; lacks Spy flavor; slightly astringent.
Middlebury, Vt.,	101	14.47	2.28	12.19	7.88	2.30	10.18	.44	86×74	Very good.	Good; more crisp than No. 100; a little better flavor.
Concord, Mass.,	87	14.51	2.14	12.37	9.14	1.53	10.67	.32	81×69	Good; 30 to 40 per cent. covered.	Very good; perhaps a trifle past prime.
Amherst, Mass.,	95	13.94	2.46	11.48	8.04	.00	8.04	.38	78×67	Rich yellow; over-color not best.	Fair to good; full ripe.
Meshoppen, Pa.,	54	15.80	2.21	13.59	7.84	2.86	10.70	.46	96×76	Good, but not brightest.	Good; lacks oils; not up to best.
Johnson, Neb.,	30	14.37	2.34	12.03	8.47	1.98	10.45	.44	Above medium	Good; yellow; over-color pale and scant.	Poor; lacks oils, sugars and acid; flat.

Kelowna, B. C., . .	100	14.63	2.21	12.42	8.12	1.99	10.11	.44	83×72	Very good; well covered; bright.	Fair and crisp; lacks flavor, though good.
Grand Isle, Vt., . .	1910	15.55	2.45	13.10	7.39	3.21	10.60	.48	–	– –	– –
Kelowna, B. C., . .	1910	15.18	2.17	13.01	7.71	3.10	10.81	.41	–	– –	– –
Baldwin.											
Amherst, Mass., . .	1	14.32	2.60	11.72	4.49	3.41	7.90	.86	Medium	Dull green and red.	Sour; not yet ripe.
Amherst, Mass., . .	98	11.15	2.11	9.04	5.84	2.41	8.25	.73	71×56	Dull green and red.	Good; acid; probably lacks sugars.
Amherst, Mass., . .	2	17.08	2.98	14.10	4.49	6.15	10.64	.63	Medium and above	Good; bright yellow and red.	Good; hardly ripe, but much riper than No. 1.
Amherst, Mass., . .	97	15.77	2.74	13.03	6.19	2.75	8.94	.43	72×62	Very good; clear, rich, bright.	Very good; a bit overripe.
Amherst, Mass., . .	3	16.10	2.76	13.34	3.74	5.53	9.27	.64	Medium and above	Clear, bright yellow; fairly well covered.	Fairly good; a little riper than No. 2; not as good.
Gypsum, O., . . .	51	17.01	2.83	14.18	6.25	4.75	11.00	.71	78×65	Fair, considerable russet.	Good; no signs of too much heat.
Meshoppen, Pa., . .	52	16.59	2.86	14.73	6.23	3.66	9.89	.68	81×63	Good; more intense than No. 51.	Good; nearly ripe.
Kelowna, B. C., . .	107	14.41	2.44	11.97	5.90	2.45	8.35	.41	84×68	Very good; bright.	Good; slight astringency; lacks flavor.
Kincaid, Kan., . .	78	16.92	2.53	14.39	7.63	4.16	11.79	.43	77×64	Good, well covered; fairly bright.	Good, mild, subacid; almost sweetish; firm texture.
Hollis, N. H., . . .	1910	16.68	2.80	13.88	5.93	3.23	9.16	.53	–	– –	– –
Kelowna, B. C., . .	1910	15.18	2.43	12.75	5.31	2.55	7.86	.52	–	– –	– –
Winesap.											
Amherst, Mass., . .	94	14.88	3.18	11.70	7.46	1.34	8.80	.52	76×61	Dull, somewhat rusty.	Poor; acid; slightly astringent; not ripe.
Wyoming, Del., . .	58	16.65	2.53	14.12	8.85	2.87	11.72	.35	78×64	Excellent; dark, rich red.	Very good; crisp and juicy; not very ripe.
Woodside, Del., . .	60	14.55	2.63	11.92	8.97	.45	9.42	.49	63×56	Fairly deep, but dull.	Good; lacks richness; a bit acid.
New Burnside, Ill., . .	34	18.89	2.83	16.06	10.88	2.24	13.12	.43	76×57	Good.	Rather poor; mealy; overripe.
Dayton, Tenn., . .	32	17.07	2.74	14.33	11.02	.75	11.77	.38	62×49	Good.	Good, but not up to best; ripe, firm, crisp.
Johnson, Neb., . .	33	19.05	2.70	16.35	10.35	2.84	13.19	.51	72×58	Good.	Fairly good; full ripe.
Kincaid, Kan., . .	76	18.24	2.81	15.43	11.06	2.92	13.98	.48	66×56	Good, fairly rich red.	Fair; lacks richness.

TABLE 7. — *Chemical Determinations* — Continued.

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
Winesap — Con.											
Manhattan, Kan.,	31	17.51	2.85	14.66	9.02	3.35	12.37	.63	Small	Deep; not very bright.	Good; ripe.
Jeff, Ala.,	59	15.70	2.61	13.09	9.75	.08	9.83	.42	68×57	Fair, pale.	Poor; lacks flavor; much overripe.
Stayman Winesap.											
Wyoming, Del.,	62	16.14	2.39	13.75	7.11	4.52	11.63	.43	80×70	Well covered, but dull.	Extremely good; tender, juicy, subacid.
Woodside, Del.,	63	16.39	3.05	13.34	8.98	2.56	11.54	.70	68×58	Fair, not intense.	Fair to good; not so rich as No. 62; more acid.
Harris Wharf, Md.,	99	14.97	2.12	12.85	8.25	3.25	11.50	.42	79×69	Fair to good; some russet.	Very good; crisp, tender, juicy.
Rome Beauty.											
Gypsum, O.,	56	15.51	2.87	12.64	6.32	3.29	9.61	.43	80×69	Good; yellow, green and bright red (one-third to two-thirds).	Fair; seems undeveloped but ripe.
Iola, Kan.,	77	13.90	2.63	11.27	6.69	2.72	9.41	.30	85×66	Rich straw-yellow and pale red (30 to 40 per cent.).	Overripe; mealy; not good.
West Fork, Ark.,	90	17.75	3.18	14.57	7.30	3.48	10.78	.51	Medium	Good; well covered; fairly bright.	Not good; lacks flavor; mealy; probably overripe, though firm.
Smith Cider.											
Landisburg, Pa.,	89	17.96	3.56	14.40	7.02	2.37	9.39	.57	81×71	Good; 50 to 60 per cent. covered; fairly bright.	Pretty good; a little overripe.
Kincaid, Kan.,	88	16.78	3.05	13.73	8.05	2.37	10.42	.44	84×68	Fair, a little pale.	Extremely poor; far overripe; very dry and mealy.

Roxbury Russet.											
Amherst, Mass.,	104	18.42	2.94	15.48	7.42	.84	8.28	.66	77×59	Good.	Very good; prime condition.
Proctorville, O.,	43	19.55	2.72	16.83	9.65	4.19	13.84	.40	73×57	Good; well russeted.	Good, somewhat wilted; ripe, or a little past.
Wyoming, Del.,	61	17.93	2.49	15.44	6.52	7.64	14.16	.70	77×58	Good, deep, even russet.	Fair to good.
Amherst, Mass.,	1910	19.03	3.14	15.89	6.96	5.93	12.89	.60	-	- -	- -
York Imperial.											
Amherst, Mass.,	96	14.38	2.89	11.49	7.67	.46	8.13	.41	78×62	Good, yellow, overcolor pale and scant.	Fair; just about ripe.
Landisburg, Pa.,	81	15.13	2.62	12.51	8.57	1.65	10.22	.37	81×65	Excellent; rich; fairly deep red.	Good, firm and crisp; just ripe; sweetish.
Wyoming, Del.,	25	15.60	2.84	12.76	7.78	2.66	10.44	.39	78×68	Good; straw-yellow; overcolor scanty.	Fair, firm and crisp; very nearly ripe.
Woodside, Del.,	57	16.02	2.70	13.32	7.28	4.01	11.29	.28	88×78	Good; fairly bright; not intense.	Good; very juicy; sweetish; barely ripe; crisp.
Dayton, Tenn.,	35	16.47	2.76	13.71	7.61	3.22	10.83	.42	79×58	Good.	Very good; just ripe.
Johnson, Neb.,	36	17.62	2.85	14.77	7.45	3.78	11.23	.49	78×68	Good.	Very good; just ripe.
Manhattan, Kan.,	37	16.20	2.45	13.75	8.68	3.40	12.08	.41	74×63	Good; a little rusty.	Very good; ripe; crisp.
Kincaid, Kan.,	79	15.81	2.59	13.22	8.55	2.53	11.08	.38	80×66	Very good; nearly covered; rich red.	Good; prime condition; not as crisp as some.
Yellow Newtown.											
Milton-on-Hudson, N. Y.,	1910	17.25	2.66	14.59	7.38	3.13	10.51	.42	-	- -	- -
Hood River, Ore.,	1910	15.70	2.83	12.87	7.79	3.00	10.79	.51	-	- -	- -
Ben Davis.											
Charlottetown, P. E. I.,	91	15.78	4.28	11.50	7.07	.46	7.53	.54	63×58	Poor; 25 to 40 per cent. covered.	Very poor; green; astringent; hard.
Abbotsford, Que.,	67	14.38	3.34	11.04	6.28	2.26	8.69	.39	66×55	Poor; not well covered.	Not ripe; about like No. 66.
Marblehead, Mass.,	66	14.21	3.61	10.60	7.24	2.41	9.50	.42	63×58	Poor; not well covered.	Not yet ripe; poor; slightly astringent; acid; tough.
Amherst, Mass.,	92	15.08	4.02	11.06	5.64	1.87	7.51	.61	75×66	Good.	Fair to good; perhaps not quite ripe.
Belleville, Ont.,	39	17.51	3.60	13.91	7.65	3.23	10.88	.42	70×58	Good.	Fair to good; not ripe; flesh greenish.

TABLE 7. — *Chemical Determinations* — Concluded.

VARIETY AND SOURCE.	Laboratory Number.	Total Solids (Per Cent.).	Insoluble Solids (Per Cent.).	Soluble Solids (Per Cent.).	Reducing Sugars (Per Cent.).	Sucrose (Per Cent.).	Total Sugars (Per Cent.).	Malic Acid (Per Cent.).	Size (Millimeters).	Color.	Quality.
Ben Davis — Con.											
South Haven, Mich., .	82	15.21	3.39	11.82	6.25	2.98	9.23	.44	70×65	Fair; 25 to 40 per cent. covered.	Fair; ripe.
Gypsum, O., . . .	65	16.53	3.28	13.25	7.46	3.32	10.78	.51	67×57	Fair; not well covered.	A little riper than No. 64; hardly as acid.
Mitchell, Ind., . . .	83	13.88	2.77	11.11	5.75	1.53	7.28	.45	80×68	Very good; all covered, striped.	Very good; prime condition.
Wyoming, Del., . .	64	15.57	3.20	12.37	6.77	3.35	10.02	.52	78×62	Very good; not well covered.	Not quite ripe; promises good.
Johnson, Neb., . .	38	15.31	2.68	12.63	6.53	3.46	9.99	.51	81×65	Excellent.	Excellent; just ripe; flesh white.
Manhattan, Kan., . .	42	15.42	2.89	12.53	6.98	3.34	10.32	.39	74×61	Good.	Good; a little more acid than No. 41.
Kincaid, Kan., . .	84	15.17	2.88	12.29	6.88	3.59	10.47	.41	81×70	Very good; like No. 83.	Very good; equal or better than No. 63.
Springdale, Ark., . .	40	15.46	3.06	12.40	7.29	1.67	8.96	.43	77×66	Fair; slightly pinkish.	Good; ripe, lacks flavoring oils; flesh white.
Bentonville, Ark., . .	41	15.64	2.86	12.78	7.44	2.35	9.79	.29	75×65	Good.	Very good; flesh white.
West Fork, Ark., . .	85	16.53	3.13	13.40	6.95	3.71	10.66	.47	Above medium	Good; dark but dull.	Mealy and dry; overripe.

VII. SUMMARY.

Some of the more important results of this work may be summarized as follows: —

1. The many variations in apple varieties arise from many causes, which may be grouped as (1) cultural, using the word in a broad sense; (2) soil; and (3) climatic. Of climatic influences, temperature is the most potent.

2. The life history of the apple may for convenience in discussion be divided into four periods: (1) growth, extending from the blossom to the attainment of full size; (2) ripening, extending to the time of harvest; (3) after ripening, extending to complete edible maturity; and (4) decay, covering the period of physiological breaking down.

3. The apple of superior table quality is high in sugars, especially sucrose, and low in insoluble solids, indicating a tender flesh and fine texture. The acid is proportionate to sugars; the ratio may vary somewhat to accord with different tastes. Good kitchen apples are wider in ratio of sugars to acid, and the proportion of insoluble solids is of little significance. Good shipping apples are high in insoluble solids.

4. In any variety of apples, high development at full maturity is marked by the attainment of full normal size for the variety, high color, well spread over the apple, and a high development of sugars, especially sucrose.

5. Each variety has a characteristic chemical composition, fairly constant when perfect maturity is attained. Most of the differences found in different samples of a variety are due to a difference in the stage of development reached.

6. The fruit of individual trees shows slight differences in size, color, form and abundance that are characteristic and not due to environmental conditions. Some of this may be due to bud variation, but it is believed that most of it is due to the interrelation of stock and scion.

7. Variation in form in the Ben Davis, and probably in other sorts as well, is due principally to the temperature during a period of about two or three weeks following blossoming. The lower the temperature the more elongated the apple. This elon-

gation is seen in apples grown near large bodies of water, which lower the temperature at this season of the year, and in seasons when the temperature is low owing to seasonal fluctuations. This influence is also seen in the form of apples in different parts of the tree. Those in the lower north portion are more elongated than those from the warmer, upper south portion.

8. Seasonal temperature affects the size of apples, a cool season resulting in smaller fruit. This is marked only in full-season varieties, and is especially noticeable in the more northerly portions of their distribution. On the other hand, in the extreme south a variety is apt to be smaller than when grown in a somewhat cooler climate.

9. For convenience in discussion, North America may be divided into seven apple belts, each having a fairly characteristic list of varieties. These are named and illustrated in the text.

10. Some varieties are of wide distribution; others more or less limited. Varietal qualities favoring a wide distribution are (1) great hardiness of tree, (2) a short season of development, (3) great vigor and ability to thrive under generally unfavorable conditions, (4) productiveness and good market qualities.

11. The northern limit of apple growing is fixed by the minimum winter temperature, and the southern limit by the heat of the hottest part of the summer, occurring usually in July or August.

12. The attainment of the highest quality, appearance and keeping quality is very largely dependent on the warmth and length of the growing season. This may be measured with fair satisfaction for the apple-growing regions of North America by an average of the mean temperatures for the months of March to September inclusive. This is called the mean summer temperature, and give temperatures ranging from 52° to 72°.

13. Factors determining the mean summer temperature in a given orchard are (1) latitude, (2) elevation, (3) site and aspect, (4) soil, (5) culture, (6) prevailing winds, (7) sunshine.

14. The optimum mean summer temperature for different varieties may be determined with fair satisfaction, and some deter-

minations are shown in Table 5. A departure of over 2° from this mean will result in less desirable fruit, though this may not be marked in short-season varieties.

15. A summer mean too low for a variety results in (1) greater acidity, (2) increased insoluble solids, (3) greater astringency, (4) less coloration, (5) decreased size, (6) scalding in storage.

16. A summer mean too high for a variety results in (1) uneven ripening, (2) premature dropping, (3) rotting on the trees, (4) poor keeping quality. (5) lack of flavor, (6) "mealiness," (7) less intense color (8) decreased size.

COMPILATIONS.

Introduction.

BY J. B. LINDSEY.

A compilation of the chemical composition of fodder articles, agricultural chemicals and manurial residues was first made by Prof. C. A. Goessmann and his assistants in 1887, and published in the fifth report of the Massachusetts State Agricultural Experiment Station, pages 181–227. This compilation included all analyses made by Goessmann and his co-workers since 1868. It was later enlarged to include compilations of the analyses made at this station of dairy products, fruits, garden crops and insecticides. The parties largely responsible for the details of the several compilations were W. H. Beal, C. S. Crocker, J. B. Lindsey, H. D. Haskins, E. B. Holland and P. H. Smith. In 1896 the classification of fodder articles was considerably modified and improved; the present compilation of agricultural chemicals and manurial residues has undergone a similar rearrangement, and the available analyses have been added to the compilation of fruits and garden crops. Naturally a few materials, being no longer of interest, have been omitted.

The tables of compilations are as follows: —

Compilation of Analyses of Fodder Articles and Dairy Products, made at Amherst, Mass., 1868-1910.[1]

P. H. SMITH AND J. B. LINDSEY.

Explanation of Table I.

Under *composition* the figures mean that each 100 pounds of the fodder contains so many pounds of water, protein, fiber, etc.

Water. — The approximate average which is likely to occur in the material is stated.

Ash refers to the residue which is left behind when the material is burned, and consists of lime, potash, soda, magnesia, iron, phosphoric and sulfuric acids.

Protein is a collective name for all of the nitrogenous matter; it corresponds to the lean meat in the animal, and may be termed

[1] Part III. of the report of Department of Plant and Animal Chemistry.

"vegetable meat." It serves as the exclusive source of flesh, as well as a source of heat or energy, and fat.

Fiber is the coarse or woody part of the plant. It may be called the plant's framework. It is a source of heat or energy and fat.

Nitrogen-free extract represents the sugars, starches and gums. It is the principal source of heat or energy and fat.

Fat includes not only the various oils and fats in all grains and coarse fodders, but also waxes, resins and coloring matters. It is also termed ether extract because it is that portion of the plant soluble in ether. It serves as a source of heat or energy and body fat.

Under *digestibility* the figures mean that so many pounds of protein, fiber, nitrogen-free extract and fat in 100 pounds of the fodder are actually digested and made use of by the animal. No feed is entirely digestible; concentrates are more digestible than coarse fodders. The data under digestibility have been worked out by actual experiment. In cases where no figures appear, data as a result of experiments are lacking.

Net Energy Value. — The entire amount of heat or energy contained in a feeding stuff is termed its total heat or energy value. All of this heat or energy cannot be utilized by the animal for the purposes of maintaining its body in a state of equilibrium, or for aiding in the production of growth and milk. The several losses may be enumerated as follows: (*a*) the undigested material, *i.e.*, the fæces; (*b*) the incompletely used material of the urine; (*c*) the work required in the processes of digestion and assimilation in preparing the nutrients so that they can be used for maintenance and for the production of growth and milk. These several sources of loss expressed as energy, deducted from the total energy, leaves the real or *net energy value.*

The calorie is the unit of energy measurement.

The small calorie represents the amount of heat required to raise 1 gram of water 1° C.

The large calorie represents the amount of heat necessary to raise 1 kilogram (1,000 grams) of water 1° C.

The therm, a name proposed by Armsby, represents the amount of heat required to raise 1,000 kilograms of water 1° C. It is to be preferred to the small or large calorie as a unit of measurement because it can be expressed in fewer figures.

In the last column of the following table, headed net energy value, is given the number of therms contained in 100 pounds of the different feeding stuffs, based on the results of very carefully conducted experiments by Kellner, a German investigator.[1]

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[1] For a full explanation of the components of the animal body, the composition of feeds, the different ways in which the food is used in the animal body and the explanation for using the therm in the calculation of rations for farm animals, see Farmers' Bulletin 346, United States Department of Agriculture, prepared by H. P. Armsby.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES.

[Figures equal percentages or pounds in 100.]

	Name.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
			Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
	I. Green Fodders.												
	(a) Meadow Grasses and Millets.												
	Johnson grass (*Andropogon halepensis*),	1	75	1.4	1.2	8.9	13.2	0.3	–	–	–	–	–
	Orchard grass (*Dactylis glomerata*),	7	70	2.1	2.9	10.4	13.7	0.9	–	–	–	–	–
	Tall oat grass (*Arrhenatherum elatius*),	4	70	1.6	2.3	10.8	14.7	0.6	–	–	–	–	–
Fox-tail millets.	Common millet (*Chætochloa Italica*),	16	80	1.0	1.5	6.5	10.5	0.5	0.9	4.6	7.0	0.3[1]	9.9
	Canary bird seed millet (*C. Italica*),	1	80	1.6	1.0	7.1	10.0	0.3	–	–	–	–	–
	Early harvest millet (*C. Italica*),	1	80	1.4	1.1	7.4	9.7	0.4	–	–	–	–	–
	Golden millet (*C. Italica*),	1	80	1.2	0.8	7.0	10.7	0.3	–	–	–	–	–
	Hungarian grass (*C. Italica*),	3	80	1.4	1.9	5.8	10.5	0.4	1.2	4.1	7.0	0.2	9.9
	Japanese millet (*C. Italica*),	12	80	1.2	1.7	6.2	10.5	0.4	0.9	3.8	7.0	0.3	9.4
Broom-corn millets.	Millet (*Panicum miliaceum*),	1	80	1.1	1.1	5.3	11.7	0.8	–	–	–	–	–
	Broom-corn millet (*P. miliaceum*),	1	80	1.2	1.3	6.4	10.7	0.4	–	–	–	–	–
	Hog millet (*P. miliaceum*),	1	80	1.4	1.5	6.5	10.2	0.4	–	–	–	–	–
	Japanese broom-corn millet (*P. miliaceum*),	2	80	1.2	0.9	6.2	11.4	0.3	–	–	–	–	–
	Barnyard millet (*Panicum crus-galli*),	8	80	1.7	1.9	6.6	9.4	0.4	1.2	4.8	6.7	0.2	9.9

[1] Same coefficients used as for Hungarian grass.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
I. GREEN FODDERS — *Con.*												
(*a*) *Meadow Grasses and Millets* — Con.												
Pearl millet (*Pennisetum spicatum*),	1	80	1.4	1.4	6.9	10.1	0.2	–	–	–	–	–
Japanese millet (variety uncertain),	3	80	1.1	1.2	7.1	10.2	0.4	0.6	4.4	6.8	0.3	8.8
(*b*) *Cereal Fodders.*												
Barley,	1	75	2.1	3.2	9.4	9.6	0.7	2.3	5.7	6.8	0.4	10.7
Barley in milk,	1	75	1.2	2.6	7.3	13.2	0.7	1.8	4.1	9.8	0.3	12.9
Corn ears (as harvested),	4	70	0.7	2.9	4.0	21.5	0.9	–	–	–	–	–
Corn husks (as harvested),	6	80	0.7	1.2	6.0	11.8	0.3	–	–	–	–	–
Corn leaves (as harvested),	4	75	2.4	3.6	6.2	12.0	0.8	–	–	–	–	–
Corn stalks (as harvested),	4	80	1.0	0.8	6.5	11.5	0.2	–	–	–	–	–
Corn fodder, Brewers Dent,	2	80	1.0	2.0	5.0	11.7	0.3	1.4	3.4	9.0	0.2	12.0
Corn fodder Early Mastodon Dent,	3	80	0.9	1.7	4.6	12.4	0.4	1.0	2.8	9.8	0.3	12.3
Corn fodder, Klondike,	1	80	1.2	1.1	5.7	11.7	0.3	–	–	–	–	–
Corn fodder, Leaming,	5	80	1.0	1.6	4.9	12.1	0.4	1.0	3.0	9.3	0.3	11.8
Corn fodder, Longfellow,	1	80	1.1	1.8	4.0	12.8	0.3	–	–	–	–	–
Corn fodder, Pride of the North,	6	80	0.9	1.7	4.3	12.6	0.5	1.1	2.8	10.2	0.4	13.2

Corn fodder, Red Cob Silage,	1	80	0.9	1.2	5.4	12.2	0.3	–	–	–	–	–
Corn fodder, Sanford White,	1	80	0.8	1.4	4.0	13.3	0.5	0.7	3.0	9.4	0.3	12.1
Corn fodder, Twitchells,	1	80	0.9	2.0	3.4	13.1	0.6	–	–	–	–	–
Corn fodder, Wings Improved Whitecap,	2	80	1.0	1.8	4.6	12.3	0.3	1.1	3.0	9.3	0.2	14.8
Corn fodder, Whitecap Yellow Dent,	2	80	0.9	1.6	4.4	12.7	0.4	–	–	–	–	–
Corn fodder, average,	76	80	1.0	1.6	4.6	12.4	0.4	0.9	2.8	9.4	0.3	11.8
Sweet corn stover,	2	80	1.2	1.4	4.9	12.0	0.5	0.7	2.8	8.8	0.4[1]	10.9
Oats (stage uncertain),	6	75	2.0	3.5	7.5	11.2	0.8	2.6	4.1	6.9	0.6[2]	11.0
Oats in bloom,	1	75	1.7	1.6	9.0	12.0	0.7	1.1	5.0	7.4	0.5[2]	9.8
Oats in milk,	1	75	1.5	2.7	8.6	11.5	0.7	2.0	4.7	7.1	0.5[2]	10.4
Oats, ripe,	1	70	1.9	1.8	10.9	14.6	0.8	–	–	–	–	–
Rye,	2	75	1.4	1.9	8.0	13.2	0.5	1.5	6.4	9.4	0.4	14.3
Winter rye in bloom,	1	75	1.6	2.7	8.3	11.8	0.6	2.1	6.6	8.4	0.4	13.9
Sorghum, Early Amber (heading out),	2	80	1.2	1.3	6.2	10.9	0.4	0.7	4.7	8.5	0.3	11.7
Sorghum, Early Amber (full blossom),	1	80	1.0	1.0	5.9	11.6	0.5	0.5	4.4	9.0	0.4	12.1
Sorghum, Early Amber (beyond full blossom),	1	80	0.9	1.2	6.4	11.2	0.3	0.5	3.5	8.2	0.2	9.5
Sorghum, average,	4	80	1.0	1.2	6.2	11.2	0.4	0.6	3.8	8.4	0.3	10.4
(c) *Legumes.*												
Alfalfa (*Medicago sativa*),	6	80	1.6	2.7	6.2	9.1	0.4	2.0	2.7	6.6	0.2	8.5
Horse bean (*Faba vulgaris*),	1	85	0.9	2.5	4.3	6.9	0.4	–	–	–	–	–
Soy bean (*Glycine hispida*),	14	80	2.1	3.5	5.4	8.1	0.9	2.7	2.4	6.2	0.5[3]	9.6
Soy bean (early white),	4	80	2.6	3.4	4.5	9.0	0.5	2.7	2.0	6.9	0.3[3]	10.2

[1] Same coefficients used as for corn fodder.
[2] Same coefficients applied to oats in several stages of growth.
[3] Same coefficients applied to all soy beans except to medium green varieties in different stages of growth.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
I. GREEN FODDERS — *Con.*												
(*c*) *Legumes* — Con.												
Soy bean (medium green),	18	80	2.3	4.1	5.2	7.8	0.6	3.2	2.4	6.0	0.3[1]	9.7
Soy bean (medium green), in bud,	1	80	2.5	4.2	5.5	7.3	0.5	3.3	2.8	5.3	0.3	9.2
Soy bean (medium green), in blossom,	5	80	2.3	4.0	5.5	7.7	0.5	3.1	2.6	5.5	0.3	9.0
Soy bean (medium green), in pod,	9	78	2.3	4.5	5.9	8.6	0.7	3.5	2.7	6.6	0.4	10.7
Soy bean (medium black),	2	80	2.5	3.8	4.7	8.0	1.0	3.0	2.1	6.2	0.6[1]	10.3
Soy bean (late),	4	80	2.6	4.6	4.2	8.0	0.6	3.6	1.9	6.2	0.3[1]	10.4
Clover, alsike (*Trifolium hybridum*),	8	80	2.3	3.3	5.4	8.5	0.5	–	–	–	–	–
Clover, crimson (*T. incarnatum*),	2	80	2.8	3.1	6.0	7.6	0.5	2.4	3.4	5.6	0.3	9.0
Clover, mammoth red (*T. medium*),	4	80	1.9	3.0	5.8	8.9	0.4	–	–	–	–	–
Clover, medium red (*T. pratense*),	13	80	1.8	3.1	5.7	8.8	0.6	2.0	3.0	6.3	0.4	9.3
Clover, medium red, in bud,	2	80	2.1	3.6	4.7	9.0	0.6	2.4	2.5	6.6	0.4[2]	10.1
Clover, medium red, in blossom,	3	79	1.9	3.5	6.0	9.0	0.6	2.3	3.2	6.5	0.4	9.9
Clover, medium red, seeding,	2	75	2.3	3.8	7.2	11.0	0.7	2.5	3.8	7.9	0.4	10.2
Sweet clover (*Melilotus alba*),	4	80	1.9	3.8	6.3	7.4	0.6	–	–	–	–	–
Cow pea (*Vigna catjang*),	12	85	2.0	2.8	3.5	6.3	0.4	2.1	2.1	5.1	0.2[3]	8.1

Cow pea, black,	6	85	2.2	2.8	3.6	6.1	0.3	2.1	2.2	4.9	0.2[3]	8.0
Cow pea, New Era,	1	85	1.9	2.6	3.6	6.4	0.5	2.0	2.2	5.2	0.3[3]	8.3
Cow pea, Whip-poor-will,	7	85	1.9	2.6	3.7	6.5	0.3	2.0	2.2	5.3	0.2[3]	8.9
Canada beauty pea (*Pisum arvense*),	1	85	1.2	2.4	4.4	6.6	0.4	–	–	–	–	–
Canada field pea (*P. arvense*),	8	85	1.3	3.2	4.3	5.8	0.4	2.6	2.1	4.4	0.2	8.0
Canada field pea (*P. arvense*), in bud,	2	85	1.1	3.2	4.1	6.1	0.5	2.6	2.5	4.3	0.3[4]	8.0
Canada field pea (*P. arvense*), in blossom,	3	87	1.2	2.8	3.8	4.8	0.4	2.3	1.7	3.6	0.2	6.1
Canada field pea (*P. arvense*), in pod,	2	84	1.2	2.3	4.8	6.3	0.4	1.9	2.2	4.8	0.2	6.9
English gray pea (*P. arvense*),	1	85	1.4	3.1	4.5	5.5	0.5	–	–	–	–	–
Prussian blue pea (*P. arvense*),	1	85	1.3	2.8	4.5	5.9	0.5	–	–	–	–	–
Flat pea (*Lathyrus sylvestris wagneri*),	2	85	1.3	4.4	3.7	5.0	0.6	–	–	–	–	–
Sainfoin (*Onobrychis sativa*),	1	75	2.1	4.4	6.0	11.6	0.9	–	–	–	–	–
Serradella (*Orinthopus sativus*),	3	85	1.6	2.2	4.4	6.5	0.3	–	–	–	–	–
Sulla (*Hedysarum coronarium*),	2	75	2.3	4.3	5.2	12.5	0.7	–	–	–	–	–
Spring vetch (*Vicia sativa*),	4	85	1.4	2.7	4.5	6.1	0.4	1.9	2.0	4.6	0.2	7.8
Winter or sand vetch (*Vicia villosa*),	7	85	2.1	3.4	4.4	4.7	0.4	2.8	2.8	3.6	0.3	7.5
Winter or sand vetch (*V. villosa*), in bud,	2	86	2.4	3.3	3.5	4.4	0.4	–	–	–	–	–
Winter or sand vetch (*V. villosa*), in blossom,	4	82	2.5	4.2	5.5	5.4	0.4	3.5	3.5	4.2	0.3	9.1
Kidney vetch (*Anthyllis vulneraria*),	1	85	2.0	2.8	2.3	7.4	0.5	–	–	–	–	–
(*d*) *Mixed and Miscellaneous.*												
Barley and peas,	1	80	1.6	2.8	6.8	8.2	0.6	2.1	3.5	5.6	0.4	8.5
Barley and vetch,	2	80	1.2	2.8	6.5	9.0	0.5	2.1	3.4	6.1	0.3[5]	8.9

[1] Same coefficients applied to all soy beans except to medium green varieties in different stages of growth. [2] Coefficients taken from the German.
[3] Same coefficients applied to all cow peas. [4] Same coefficients applied to Canada field peas in blossom and in pod. [5] Same coefficients used as for barley and peas.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
I. GREEN FODDERS — *Con.*												
(*d*) *Mixed and Miscellaneous* — Con.												
Corn and soy bean,	3	80	1.5	2.6	5.0	10.4	0.5	–	–	–	–	–
Corn and cow peas,	1	80	1.8	2.1	5.3	10.4	0.4	–	–	–	–	–
Sweet corn and cow peas,	4	80	1.7	1.7	5.2	10.9	0.5	–	–	–	–	–
Millet and peas,	1	80	1.8	2.4	7.5	8.0	3.0	–	–	–	–	–
Tall oat grass and alsike clover,	2	80	1.5	2.7	5.8	9.5	0.5	–	–	–	–	–
Orchard grass and alsike clover,	1	80	1.5	2.4	6.5	9.0	0.7	–	–	–	–	–
Peas and oats,	4	80	1.7	2.9	6.0	8.8	0.6	2.1	3.8	6.3	0.4	10.0
Sorghum and cow peas,	1	80	1.6	1.6	6.5	9.9	0.4	–	–	–	–	–
Vetch and oats (1–1),	3	80	1.8	3.0	6.3	8.4	0.5	2.3	4.3	5.7	0.2	9.6
Vetch and oats (1–4),	1	80	1.8	2.7	6.0	8.8	0.7	–	–	–	–	–
Wheat and vetch,	4	80	1.6	3.4	6.4	8.1	0.5	2.6	4.4	5.9	0.3	10.4
Apple pomace,	6	83	0.6	1.0	2.9	11.6	0.9	–	1.9	9.9	0.4	11.7
Sugar beet pulp,	1	90	0.1	1.4	2.5	5.9	0.1	0.9	2.1	5.0	–	–
Cabbage waste,	1	82	4.9	3.6	2.6	6.6	0.3	–	–	–	–	–

Carrot tops,	1	80	2.8	4.2	2.7	9.9	0.4	–	–	–	–	–
Prickley comfrey (*Symphytum asperrimum*),	1	87	2.8	2.3	1.5	6.1	0.3	–	–	–	–	–
Purslane (*Portulaca oleracea*),	1	91	1.5	2.3	1.6	3.4	0.2	–	–	–	–	–
Dwarf Essex rape (*Brassica napus*),	1	85	2.4	1.9	2.9	7.2	0.6	1.7	2.5	6.6	0.3[1]	10.3
Summer rape (*B. napus*),	1	85	2.8	2.1	2.7	6.9	0.5	1.9	2.3	6.3	0.2	9.9
Winter rape (*B. napus*),	1	85	3.3	2.3	1.8	7.1	0.5	2.0	1.6	6.5	0.2	9.1
Sorghum (*Andropogon sorghum*),	7	80	1.3	1.7	5.5	11.1	0.4	0.8	3.4	8.3	0.3	10.6
Spurry (*Spergula arvensis*),	1	72	2.6	2.9	7.0	15.4	0.1	–	–	–	–	–
Teosinte (*Euchlæna Mexicana*),	2	70	2.3	2.3	9.4	15.6	0.4	–	–	–	–	–
II. Silage.												
Apple pomace,	1	85	0.6	1.2	3.3	8.8	1.1	–	2.2	7.5	0.5[2]	9.4
Corn,	49	80	1.1	1.7	5.4	11.1	0.7	0.9	3.5	7.7	0.5	10.6
Corn and soy bean,	6	76	2.3	2.7	7.3	10.9	0.8	1.7	4.5	8.5	0.7	12.6
Millet,	3	74	2.4	1.7	7.5	13.6	0.8	–	–	–	–	–
Millet and soy bean,	9	79	2.8	2.8	7.2	7.2	1.0	1.6	5.0	4.2	0.7	8.4
III. Hay and Dry Coarse Fodders.												
(a) Meadow Grasses and Millets.												
Canada blue grass (*Poa compressa*),	1	14	4.8	5.9	31.3	42.1	0.9	2.5	22.2	26.5	0.3	36.0
Kentucky blue grass (*Poa pratensis*),	3	14	6.4	7.7	30.5	39.7	1.7	4.4	20.1	24.2	0.9	35.0
Canada hay,	4	14	4.6	6.1	28.1	45.1	2.1	–	–	–	–	–
English hay (mixed grasses),	122	14	5.3	7.9	27.8	42.8	2.2	4.5	17.2	26.5	1.1	36.9
Fermented hay,	1	14	6.3	8.4	25.4	43.7	2.2	–	–	–	–	–

[1] Same coefficients applied to all varieties of rape.

[2] Same coefficients used as for fresh apple pomace.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
III. HAY AND DRY COARSE FODDERS — *Con.*												
(*a*) *Meadow Grasses and Millets* — Con.												
Meadow fescue (*Festuca elatior pratensis*),	7	14	7.1	5.8	32.2	39.3	1.6	3.0	21.6	23.2	0.9	30.3
Millets. Barnyard grass (*Panicum crus-galli*),	1	14	8.6	13.1	29.0	33.6	1.7	–	–	–	–	–
Millets. Barnyard millet (*P. crus-galli*),	8	14	7.3	8.2	28.4	40.4	1.7	5.2	17.6	21.0	0.8	30.7
Millets. Hungarian grass (*Chætochloa Italica*),	3	14	6.3	8.4	24.6	45.0	1.7	5.0	16.7	30.2	1.1	42.4
Orchard grass (*Dactylis glomerata*,)	7	14	5.9	8.3	29.9	39.3	2.6	5.0	18.2	21.6	1.4	32.1
Tall oat grass (*Arrhenatherum elatius*),	4	14	4.6	6.4	30.9	42.1	1.9	3.3	17.0	24.4	1.1	30.8
Red top (*Agrostis alba vulgaris*),	6	14	4.6	6.5	28.5	44.9	1.5	4.0	17.4	27.8	0.8	36.6
Red top (*A. alba vulgaris*). early cut,	1	14	4.3	5.8	30.9	43.3	1.7	–	–	–	–	–
Red top (*A. alba vulgaris*), late cut,	1	14	4.1	6.0	31.0	43.2	1.7	–	–	–	–	–
Rowen,	32	14	6.5	11.4	24.1	41.0	3.0	7.9	15.9	26.2	1.4	41.1
Italian rye grass (*Lolium Italicum*),	4	14	6.4	7.1	28.6	42.2	1.6	–	–	–	–	–
Perennial rye grass (*Lolium perenne*),	4	14	7.9	10.1	25.4	40.5	2.1	–	–	–	–	–
Salt hays. Black grass (*Juncus Gerardi*),	3	16	7.4	7.0	24.3	43.1	2.2	4.1	14.3	22.4	1.0	28.7
Salt hays. Branch grass (*Distichlis spicata*),	2	16	7.6	6.8	22.4	45.1	2.1	3.8	12.1	22.1	0.7	28.1
Salt hays. Flat sage (*Spartina stricta maritima* var.),	1	16	8.2	6.6	25.0	41.8	2.4	3.4	15.0	23.0	0.9	30.6

Salt hays. Fox grass (*Spartina patens*),	2	16	5.8	6.7	22.5	46.9	2.1	4.0	11.9	24.9	0.8	31.3
Salt hays. High-grown salt hay (largely *Spartina patens*),	1	16	7.0	6.3	22.2	46.4	2.1	3.8	11.8	24.6	0.8	30.8
Salt hays. Cove mixture (black grass and red top),	1	16	6.0	7.4	23.2	45.6	1.8	3.6	13.9	24.2	0.7	31.6
Salt hays. Mixed salt hay (largely fox grass and branch grass),	1	16	8.4	5.5	22.5	45.5	2.1	2.3	13.1	23.7	0.6	29.1
Salt hays. Salt hay (variety uncertain),	2	16	4.3	3.4	24.0	49.8	2.5	-	-	-	-	-
Swamp or swale hay,	2	14	5.8	7.1	26.7	44.5	1.9	2.4	8.8	20.5	0.8	19.6
Timothy (*Phleum pratense*),	9	14	4.1	8.0	28.3	43.7	1.9	3.8	14.2	27.1	1.0	30.8
Timothy (*P. pratense*), early cut,	1	14	4.0	5.7	31.0	43.5	1.8	3.2	17.7	27.4	0.9	34.3
Timothy (*P. pratense*), late cut,	1	14	3.9	5.2	29.7	45.2	2.0	2.2	13.7	26.7	1.0	29.2
White top (*Agrostis vulgaris* var.),	1	14	6.0	11.2	24.4	41.5	2.9	-	-	-	-	-
(b) *Cereal Fodders.*												
Corn stover, from field,	46	40	3.9	4.6	20.6	30.1	0.8	1.7	13.2	17.8	0.6	23.4
Corn stover, very dry,	46	20	5.2	6.1	27.5	40.2	1.0	2.3	17.6	23.7	0.7	31.0
Oats,	6	15	6.9	11.7	25.5	38.3	2.6	6.2	13.0	21.1	1.6	30.4
(c) *Legumes.*												
Alfalfa, first cutting,	3	15	6.6	14.3	27.2	35.3	1.5	10.3	13.6	24.4	0.5	35.4
Alfalfa, second cutting,	1	15	5.7	13.0	32.3	32.9	1.1	10.0	14.9	24.3	0.5	33.3
Alsike clover,	8	15	9.7	14.0	23.1	36.1	2.1	9.2	11.6	23.8	0.8	34.6
Mammoth red clover,	4	15	8.2	13.1	24.4	37.6	1.7	-	-	-	-	-
Medium red clover, bud to early blossom,	1	15	9.5	15.1	24.1	34.6	1.7	9.7	14.2	23.5	0.9	37.2
Medium red clover, full blossom,	1	15	7.6	13.0	25.4	37.4	1.6	7.8	11.7	25.8	0.9	34.2
Medium red clover,	15	15	7.7	13.3	24.3	37.2	2.5	7.7	13.1	24.2	1.4	35.6

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
III. HAY AND DRY COARSE FODDERS — *Con.*												
(d) Straw.												
Barley,	2	15	4.8	6.5	32.2	39.0	2.5	1.3	18.0	21.1	1.1[1]	25.5
Horse bean,	1	15	8.1	8.3	35.2	32.1	1.3	–	–	–	–	–
Soy bean,	3	15	6.1	4.7	36.1	36.3	1.8	2.4	13.7	24.0	1.1[1]	31.2
Millet (*Chætochloa Italica*),	1	15	5.3	3.6	35.2	39.5	1.4	–	–	–	–	–
Millet (*Panicum crus-galli*),	1	15	4.6	5.2	30.4	42.7	2.1	–	–	–	–	–
Millet (*P. miliaceum*),	1	15	5.2	3.3	35.9	38.1	2.5	–	–	–	–	–
Millet (variety uncertain),	1	15	5.8	4.2	35.5	38.3	1.2	–	–	–	–	–
Wheat,	1	15	4.1	6.2	30.5	42.8	1.4	0.7	15.9	16.3	0.4[1]	17.2
(e) Mixed and Miscellaneous.												
Hairy lotus,	2	15	7.0	12.6	16.8	46.1	2.5	–	–	–	–	–
Oat grass and alsike clover,	2	15	6.5	11.6	24.5	40.1	2.3	–	–	–	–	–
Orchard grass and alsike clover,	1	15	6.6	10.1	27.6	38.3	2.4	–	–	–	–	–
Peas and oats,	4	15	7.2	12.2	25.5	37.5	2.6	8.9	14.8	22.9	1.5	36.7
Vetch and oats (1-1),	3	15	7.4	12.8	26.7	35.8	2.3	8.3	13.1	21.1	1.4	31.4
Wheat and vetch,	4	15	6.8	14.5	27.2	34.4	2.1	10.7	17.7	23.4	1.3	40.7
White daisy,	1	15	6.0	6.6	30.7	39.7	2.0	–	–	–	–	–

IV. VEGETABLES, FRUITS, ETC.												
Apples,	2	78	0.7	1.0	1.5	18.3	0.5	–	–	–	–	–
Artichokes,	1	78	1.1	2.9	0.9	16.9	0.2	–	–	–	–	–
Beets, red,	7	88	1.1	1.5	0.7	8.6	0.1	–	–	–	–	–
Sugar beets,	13	86	0.9	1.6	0.9	10.5	0.1	1.5	0.9	10.5	0.1	10.5
Yellow fodder beets,	4	89	1.0	1.3	1.0	7.5	0.2	1.0	–	4.2	–	3.3
Cabbages,	1	90	0.8	2.6	0.9	5.5	0.2	–	–	–	–	–
Carrots,	5	89	0.9	1.0	1.1	7.8	0.2	–	–	–	–	–
Cranberries,	1	89	0.2	0.5	1.2	8.5	0.6	–	–	–	–	–
Mangolds,	5	88	1.2	1.4	0.8	8.5	0.1	1.0	0.3	7.7	–	6.9
Parsnips,	1	80	1.5	1.3	1.5	15.0	0.7	–	–	–	–	–
Potatoes,	54	80	0.8	2.1	0.5	16.5	0.1	1.0	–	14.8	–	16.9
Potatoes,	125	80	–	–	–	14.3[2]	–	–	–	–	–	–
Ruta-bagas,	3	89	1.1	1.2	1.3	7.2	0.2	1.0	1.0	6.8	0.2	7.6
Japanese radish,	1	93	0.7	0.5	0.7	5.0	0.1	–	–	–	–	–
Turnips,	5	90	0.9	1.5	1.2	6.6	0.2	1.4	1.2	6.3	0.2	7.7
V. CONCENTRATED FEEDS.												
(a) *Protein.*												
Alfalfa meal,	1	9	8.0	13.2	32.7	35.8	1.3	9.8	15.0	25.8	0.5[3]	31.2
Horse beans,	1	14	3.8	25.8	7.0	48.6	0.8	–	–	–	–	–
Red adzinki beans,	2	14	3.6	21.0	4.0	56.7	0.7	–	–	–	–	–
Saddle beans,	1	14	5.3	13.0	4.1	49.4	14.2	–	–	–	–	–
Soy bean,	5	14	5.0	31.2	4.7	28.4	16.7	28.4	–	23.0	15.5	91.7

[1] Digestion coefficients taken from the German. [2] Starch. [3] Same coefficients used as for alfalfa hay.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
V. CONCENTRATED FEEDS — *Con.*												
(*a*) *Protein* — Con.												
Soy bean (medium green),	3	14	4.6	35.3	4.0	24.3	17.8	32.1	–	19.7	16.6	94.7
Soy bean cake,	1	8	5.4	41.6	4.8	31.6	8.6	–	–	–	–	–
Blood meal, Armour's edible,	3	11	3.1	84.3	–	1.2	0.4	70.8	–	–	–	–
Brewers' dried grains,	19	10	3.6	24.0	13.4	42.8	6.2	19.4	6.6	24.4	5.5	56.4
Brewers' wet grains,	1	77	0.7	6.7	3.8	9.8	2.0	5.3	2.0	5.7	1.8	15.2
Buckwheat feed,	2	10	3.2	15.9	22.0	44.8	4.1	–	–	–	–	–
Buckwheat middlings,	3	10	4.7	26.7	6.8	44.6	7.2	22.7	1.1	37.0	6.4	76.8
Calf meal (Schumachers),	2	9	2.2	18.7	2.0	60.2	7.9	–	–	–	–	–
Cocoanut meal,	3	9	4.7	20.4	11.0	40.6	4.3	–	–	–	–	–
Cottonseed meal,	404	7	6.7	44.6	6.5	25.2	10.0	37.5	2.3	19.7	9.4	80.8
Cottonseed meal (low grade),	33	8	4.6	24.9	18.0	37.0	7.5	18.9	7.0	27.0	7.1	62.2
Dairy feed, Union Grains,	1	7	6.2	25.2	9.9	44.1	7.6	19.2	9.2	37.9	7.4	–
Dairy feed Buffalo Creamery,	1	9	4.3	19.9	12.4	50.2	4.2	16.1	6.8	35.6	3.7	–
Dairy feed, Unicorn,	1	8	3.3	27.3	9.0	46.1	6.3	21.3	6.5	41.0	6.0	–
Distillers' dried grains, largely from corn,	81	8	1.7	31.7	12.3	34.1	12.2	23.1	11.7	27.6	11.6	80.2

Gluten feed,	278	8.5	1.9	25.9	7.2	53.3	3.2	22.0	6.3	48.0	2.6	77.8
Gluten flour, wheat,	1	5.5	0.4	84.8	0.2	8.1	1.0	-	-	-	-	-
Gluten meal, wheat,	2	8.0	0.9	39.8	0.8	48.9	1.6	-	-	-	-	-
Gluten meal,	139	9.5	1.0	36.0	2.1	49.1	2.3	31.7	-	43.2	2.1	74.9
Germ oil meal,	13	9.0	2.7	22.7	9.3	45.9	10.4	15.7	-	37.2	10.1	79.4
Flax screenings,	2	8.0	6.0	16.8	13.7	40.9	14.6	-	-	-	-	-
Flaxseed meal,	2	7.0	3.5	23.5	5.5	23.3	37.2	-	-	-	-	-
Linseed meal (new process),	58	9.0	5.6	37.4	8.9	36.4	2.7	31.5	6.6	29.1	2.4	72.7
Linseed meal (old process),	138	8.5	5.2	34.3	8.5	36.4	7.1	30.5	4.8	28.4	6.3	80.3
Malt sprouts,	32	11.0	5.9	26.4	12.3	43.1	1.3	20.1	12.2	36.6	1.1	56.4
Bibby's dairy cake,	4	10.0	7.7	19.7	8.6	44.9	9.1	13.0	4.0	36.4	8.4	-
Holstein sugar feed,	1	8.0	6.7	12.6	10.0	60.0	2.7	8.3	4.4	48.6	2.4	-
Sucrene dairy feed,	9	9.0	6.4	16.9	11.4	52.0	3.3	10.3	8.2	38.0	3.1	-
Oat middlings, fine,	4	9.0	2.3	15.8	2.4	64.3	6.2	12.8	1.2	61.7	5.8	92.2
Pea meal,	1	10.0	2.6	18.9	17.5	49.4	1.6	15.7	4.6	46.4	0.9	70.4
Peanut bran,	2	5.0	4.8	19.2	9.1	33.6	28.3	-	-	-	-	-
Peanut germ,	2	3.0	3.4	28.5	3.3	18.4	43.4	-	-	-	-	-
Peanut meal,	1	8.0	4.0	49.0	3.5	24.7	10.8	44.6	0.8	22.7	9.6	94.1
Rye feed,	20	11.0	3.3	14.8	3.8	64.4	2.7	11.8	-	56.7	2.4	78.2
Sun flower seed cake,	1	10.0	4.2	34.8	10.9	21.8	18.3	-	-	-	-	-
Wheat middlings (flour),	140	10.0	3.2	18.8	3.3	59.9	4.8	16.5	1.2	52.7	4.1	83.8
Wheat middlings (standard),	371	10.0	4.3	17.8	7.0	55.9	5.0	13.8	2.1	43.5	4.4	57.6
Wheat mixed feed, bran and middlings,	859	10.0	5.3	16.9	8.1	55.2	4.5	13.2	5.0	42.5	3.9	-

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	
V. CONCENTRATED FEEDS — *Con.*												
(a) *Protein* — Con.												
Wheat mixed feed, adulterated,	7	10.0	4.3	12.3	15.5	54.6	3.3	7.7	4.3	38.8	3.0	-
Wheat bran,	452	10.0	6.2	16.1	10.0	53.3	4.4	12.4	3.9	37.8	2.8	49.0
Wheat bran (spring),	4	10.0	5.8	16.1	10.5	52.6	5.0	12.2	4.6	38.9	3.2	-
Wheat bran (winter),	3	10.0	6.2	15.3	8.6	57.0	2.9	11.8	2.3	37.1	1.9	-
Wheat screenings,	1	8.0	4.9	15.6	9.1	54.7	7.7	11.7	5.9	46.5	7.2	-
(b) *Starchy.*												
Bakery refuse,	1	13.0	10.1	8.0	0.3	63.0	5.6	-	-	-	-	-
Barley,	7	12.0	2.5	11.4	5.7	66.6	1.8	10.0	4.0	61.9	1.5	82.3
Dried beet pulp,	2	10.0	3.3	9.1	18.6	58.3	0.7	-	-	-	-	-
Dried molasses beet pulp,	4	8.0	5.8	9.9	14.1	61.7	0.5	6.3	11.8	56.1	-	72.1
Broom corn seed,	3	12.0	2.7	10.4	7.4	64.2	3.3	-	-	-	-	-
Buckwheat,	1	12.0	1.9	9.9	10.3	63.5	2.4	-	-	-	-	-
Cassava starch refuse,	1	12.0	1.6	0.8	6.1	78.8	0.7	-	-	-	-	-
Cocoa dust,	1	7.0	6.3	14.4	5.5	42.7	24.1	-	-	-	-	-
Cocoa shells,	1	5.0	8.4	18.0	15.9	50.9	1.8	-	-	-	-	-

Cocoanut meat,	1	1.0	0.8	9.9	7.5	15.3	65.5	–	–	–	–	–
Corn bran,	2	11.0	2.0	10.8	12.4	59.8	4.0	5.8	7.3	46.0	3.1	66.5
Corn cobs,	15	8.0	1.4	2.2	32.2	55.8	0.4	0.4	20.9	33.5	0.2	28.9
Corn and cob meal,	38	11.0	1.4	8.9	6.7	68.4	3.6	4.6	3.0	60.2	3.0	–
Corn kernels,	119	11.0	1.3	9.8	2.0	72.0	3.9	–	–	–	–	–
Corn kernels,	16	14.0	–	–	–	60.3[1]	–	–	–	–	–	–
Corn meal,	119	11.0	1.3	9.8	2.0	71.9	3.9	6.6	–	66.1	3.5	85.5
Sweet corn kernels,	3	11.0	1.9	12.5	2.4	64.9	7.3	–	–	–	–	–
Corn and oat feed,	48	10.0	3.0	9.1	9.9	64.8	3.2	–	–	–	–	–
Corn and oat feed (Victor),	39	10.0	3.5	8.6	11.3	62.9	3.7	6.1	5.4	52.2	3.2	–
Corn, oat and barley feed,	8	10.0	3.1	11.4	8.3	62.4	4.8	–	–	–	–	–
Corn, oat and barley feed (Schumachers),	15	8.0	4.0	11.3	11.8	60.4	4.5	7.9	6.1	47.7	4.0	–
Corn screenings,	1	11.0	2.1	7.4	2.9	72.6	4.0	–	–	–	–	–
Cotton hulls,	5	11.0	2.6	5.3	39.7	39.0	2.4	–	15.9	16.0	2.1	–
Cotton-hull bran,	1	11.0	1.9	2.3	35.0	48.7	1.1	–	–	–	–	–
Cottonseed feed,	4	11.0	3.1	10.5	36.0	35.9	3.5	5.4	16.6	19.8	3.0	43.1
Flax bran (stalks and pods),	1	7.0	12.1	6.2	45.1	27.4	2.2	–	–	–	–	–
Hominy meal,	239	11.0	2.5	10.4	4.2	63.9	8.0	6.8	2.8	57.0	7.2	89.6
Mellen's food refuse,	1	7.0	3.9	11.4	7.1	67.2	3.4	–	–	–	–	–
Millet seed,	4	12.0	2.6	11.1	7.7	62.9	3.7	–	–	–	–	–
Barnyard millet seed,	1	11.0	3.3	12.2	7.6	60.3	5.6	–	–	–	–	–
Molasses, Porto Rico (low grade),	15	26.0	6.2	3.2	–	64.6	–	–	–	–	–	–

[1] Starch.

TABLE I. — COMPOSITION AND DIGESTIBILITY OF FODDER ARTICLES — *Concluded.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Composition.						Digestibility.				Net Energy Values (Therms).
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Protein.	Fiber.	Nitrogen free Extract.	Fat.	
CONCENTRATED FEEDS — *Con.*												
(*b*) *Starchy* — Con.												
Oat kernels,	10	11.0	3.0	12.5	8.5	60.4	4.6	10.7	2.6	47.7	3.8[1]	69.7
Oats, ground,	10	12.0	3.0	12.3	8.4	59.7	4.6	10.1	1.2	51.3	3.7[1]	71.2
Oat feed,	122	7.0	5.5	7.9	21.8	55.0	2.8	5.1	7.0	23.1	2.5	40.9
Oat feed (low grade),	17	7.0	5.5	5.1	26.4	54.4	1.6	3.2	8.4	18.0	1.5	33.2
Oat feed, Canada,	2	7.0	5.4	13.2	24.8	44.7	4.9	9.1	8.2	22.8	4.3	49.5
Pea bran,	2	11.0	2.7	10.0	39.7	35.6	1.0	–	–	–	–	–
Peanut shells, ground,[2]	5	9.4	2.4	7.4	60.6	16.9	3.3	–	–	–	–	–
Rice, cleaned,	1	11.0	0.3	8.5	0.1	79.8	0.3	–	–	–	–	–
Rice, bran,	2	11.0	12.7	6.8	20.6	42.8	6.1	4.3	6.0	33.4	5.4	–
Rice meal,	2	11.0	8.2	11.8	5.3	50.8	12.9	7.3	–	46.7	11.7	87.7
Rye middlings,	1	11.0	3.6	11.7	3.3	65.4	5.0	–	–	–	–	–
Speltz,	1	8.0	3.9	11.5	11.1	62.9	2.2	9.2	6.7	56.0	1.9	–
Starch refuse,	2	12.0	1.8	4.8	3.8	76.3	1.3	–	–	–	–	–
Red wheat kernels,	1	12.0	1.7	8.8	2.6	72.4	2.5	5.9	1.0	66.6	2.0	78.9
White winter wheat kernels,	1	12.0	1.7	11.5	2.1	70.8	1.9	9.4	1.6	65.8	1.2	80.3

Wheat kernels,	13	12.0	1.8	12.0	2.6	69.7	1.9	9.0	1.5	64.8	1.4	78.9
Wheat flour,	2	12.0	0.4	9.9	0.1	76.8	0.8	–	–	–	–	–
(c) Poultry.												
Green cut bone,	2	27.0	19.2	18.6	–	5.8	29.4	–	–	–	–	–
Raw ground bone,	1	8.0	64.4	23.9	–	3.4	0.3	–	–	–	–	–
Cut clover,	2	10.0	6.8	17.9	20.5	41.8	3.0	–	–	–	–	–
Meat and bone meal,	38	6.0	37.3	39.6	–	6.3	10.8	–	–	–	–	–
Meat scrap,	12	9.0	18.4	50.6	–	4.2	17.8	–	–	–	–	–
Rava meat meal,	1	10.0	1.7	83.2	–	–	5.1	–	–	–	–	–
Mutton scrap,	1	7.0	33.1	39.9	–	5.3	14.7	–	–	–	–	–
Fish glue waste,	1	14.0	34.9	39.1	–	4.1	7.9	–	–	–	–	–
Milk albumen,	1	11.0	31.4	42.4	–	14.4	0.8	–	–	–	–	–
Granulated milk,	1	10.0	26.5	35.9	–	18.1	9.6	–	–	–	–	–

[1] Coefficients obtained from digestion experiments with horses.

[2] Valueless for feeding.

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES.[1]

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. GREEN FODDERS.					
(a) Meadow Grasses and Millets.					
Orchard grass,	4	70	0.43	0.56	0.13
Millet,	1	80	0.29	0.43	0.11
Barnyard millet,	3	80	0.30	0.67	0.10
Hungarian grass,	1	80	0.30	0.42	0.12
Japanese millet,	3	80	0.33	0.22	0.10
(b) Cereal Fodders.					
Corn fodder,	22	80	0.39	0.30	0.13
Oats,	3	75	0.72	0.56	0.19
Rye,	2	75	0.27	0.57	0.11
(c) Legumes.					
Alfalfa,	4	80	0.44	0.31	0.11
Horse bean,	1	85	0.41	0.21	0.05
Soy bean (early white),	1	80	0.57	0.55	0.13
Soy bean (medium green), average,	14	80	0.64	0.53	0.14
Soy bean (medium green), in bud,	1	80	0.66	0.58	0.15
Soy bean (medium green), in blossom,	5	80	0.64	0.60	0.13
Soy bean (medium green) in pod,	7	78	0.72	0.52	0.17
Soy bean (medium black),	1	80	0.70	0.50	0.16
Soy bean (late),	1	80	0.60	0.68	0.14
Alsike clover,	6	80	0.53	0.50	0.15
Mammoth red clover,	3	80	0.50	0.27[2]	0.12
Medium red clover, average,	10	80	0.52	0.57	0.11
Medium red clover, in bud,	2	80	0.58	0.71	0.13
Medium red clover, in blossom,	3	79	0.51	0.58	0.12
Medium red clover, seeding,	2	75	0.61	0.65	0.13
Sweet clover,	1	80	0.43	0.40	0.12
White lupine,	1	85	0.45	0.26	0.05
Yellow lupine,	1	85	0.40	0.44	0.09
Canada field peas, average,	6	85	0.50	3.08	0.12

[1] Many of these analyses were made in earlier years by the Massachusetts State Experiment Station. The percentages of the several ingredients will vary considerably depending upon the fertility of the soil, and especially upon the stage of growth of the plant. In the majority of cases the number of samples analyzed is too few to give a fair average. The figures, therefore, must be regarded as close approximations rather than as representing absolutely the exact fertilizing ingredients of the different materials. (J. B. L.)

[2] Evidently below normal.

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
I. GREEN FODDERS — *Con.*					
(c) *Legumes* — Con.					
Canada field peas, in bud,	2	85	0.50	0.44	0.11
Canada field peas, in blossom,	2	87	0.45	0.32	0.11
Canada field peas, in pod,	2	84	0.52	0.37	0.13
Cow pea, average,	9	85	0.45	0.47	0.12
Black cow peas,	4	85	0.40	0.47	0.12
Whip-poor-will cow peas,	5	85	0.49	0.47	0.12
Flat pea,	1	85	0.75	0.32	0.10
Small pea,	1	85	0.40	0.31	0.09
Sainfoin,	1	75	0.68	0.57	0.20
Serradella,	2	85	0.36	0.37	0.12
Sulla,	2	75	0.68	0.58	0.12
Spring vetch,	1	85	0.36	0.45	0.10
Hairy or sand vetch, average,	5	85	0.55	0.51	0.13
Hairy or sand vetch, in bud,	2	86	0.52	0.54	0.12
Hairy or sand vetch, in blossom,	3	82	0.65	0.57	0.16
Kidney vetch,	1	85	0.44	0.28	0.08
Average for legumes,	–	–	0.53	0.44	0.12
(d) *Mixed and Miscellaneous.*					
Vetch and oats,	4	80	0.30[1]	0.30	0.14
Apple pomace,	2	83	0.21	0.12	0.02
Carrot tops,	1	80	0.69	1.08	0.13
Prickley comfrey,	1	87	0.37	0.76	0.12
Common buckwheat,	1	85	0.44	0.54	0.09
Japanese buckwheat,	1	85	0.26	0.53	0.14
Silver-hull buckwheat,	1	85	0.29	0.39	0.14
Summer rape,	1	85	0.34	0.78	0.10
Sorghum,	8	80	0.26	0.29	0.11
Teosinte,	1	70	0.47	1.18	0.90
II. SILAGE.					
Corn,	7	80	0.42	0.39	0.13
Corn and soy bean,	1	76	0.65	0.36	0.35[2]
Millet,	3	74	0.26	0.62	0.14
Millet and soy bean,	5	79	0.42	0.44	0.11

[1] Too low; 0.43 nearer correct.

[2] Evidently too high.

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
III. HAY AND DRY COARSE FODDERS.					
(a) Meadow Grasses and Millets.					
Barnyard millet,	3	14	1.29	2.88	0.43
Hungarian grass,	1	14	1.29	1.79	0.52
Italian rye grass,	4	14	1.12	1.19	0.53
Kentucky blue grass,	2	14	1.20	1.54	0.39
Meadow fescue,	6	14	0.93	1.98	0.37
Orchard grass,	4	14	1.23	1.60	0.38
Perennial rye grass,	2	14	1.16	1.47	0.53
Red-top,	4	14	1.07	0.95	0.33
Timothy,	3	14	1.20	1.42	0.33
English hay (mixed grasses),	13	14	1.34	1.61	0.32
Rowen,	13	14	1.72	1.58	0.48
Branch grass,	1	16	1.06	0.87	0.19
Fox grass,	1	16	1.18	0.95	0.18
Salt hay (variety uncertain),	1	16	1.05	0.64	0.23
(b) Cereal Fodders.					
Corn stover, from field,	17	40	0.69	0.92	0.20
Corn stover, very dry,	17	20	0.92	1.22	0.26
Oats,	3	15	2.45[1]	1.90	0.65
(c) Legumes.					
Alsike clover,	6	15	2.26	2.10	0.63
Mammoth red clover,	3	15	2.14	1.16[2]	0.52
Medium red clover,	10	15	2.21	2.42	0.47
(d) Straw.					
Barley,	2	15	0.95	2.03	0.19
Soy bean,	1	15	0.69	1.04	0.25
Millet,	1	15	0.68	1.73	0.18
(e) Mixed and Miscellaneous.					
Vetch and oats,	4	15	1.29[3]	1.27	0.60
Broom corn waste (stalks),	1	10	0.87	1.87	0.47
Palmetto root,	1	12	0.54	1.37	0.16
Spanish moss,	1	15	0.61	0.56	0.07
White daisy,	1	15	0.26	1.18	0.41

[1] Too high; 1.90 nearer correct. [2] Evidently below normal.
[3] Too low; 1.80 nearer correct.

Table II. — Fertilizer Ingredients of Fodder Articles — *Continued.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
IV. Vegetables, Fruits, etc.					
Apples,	2	78	0.12	0.17	0.01
Artichokes,	1	78	0.46	0.48	0.17
Beets, red,	8	88	0.24	0.44	0.09
Sugar beets,	4	86	0.24	0.52	0.11
Yellow fodder beets,	1	89	0.23	0.56	0.11
Mangolds,	3	88	0.15	0.34	0.14
Carrots,	3	89	0.16	0.46	0.09
Cranberries,	1	89	0.08	0.10	0.03
Parsnips,	1	80	0.22	0.62	0.19
Potatoes,	5	80	0.29	0.51	0.08
Japanese radish,	1	93	0.08	0.40	0.05
Turnips,	4	90	0.17	0.38	0.12
Ruta-bagas,	3	89	0.19	0.49	0.12
V. Concentrated Feeds.					
(*a*) *Protein.*					
Red adzinki bean,	1	14	3.27	1.55	0.95
White adzinki bean,	1	14	3.45	1.53	1.00
Saddle bean,	1	14	2.08	2.09	1.49
Soy bean,	3	14	5.61	2.12	1.82
Blood meal (Armour's),	1	11	13.55	0.18	0.26
Brewers' dried grains,	2	8	3.68	0.86	1.06
Cottonseed meal,	167	7	7.08	2.05	2.90
Distillers' dried grains,	20	8	4.50	0.31	0.61
Gluten feed,	106	8.5	4.13	0.40	0.77
Gluten meal,	46	9.5	5.87	0.21	0.55
Linseed meal (new process),	21	9	5.97	1.42	1.79
Linseed meal (old process),	56	8.5	5.35	1.30	1.66
Malt sprouts,	12	11	4.32	2.00	1.56
Bibby's dairy cake,	1	10	2.94	1.67	2.07
Sucrene feed,	1	10	2.62	2.08	0.55
Pea meal,	1	10	3.04	0.98	1.81
Peanut meal,	1	8	7.84	1.54	1.27
Proteina,	1	8	3.04	0.58	1.02

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Continued.*

[Figures equal percentages or pounds in 100.]

NAME.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
V. CONCENTRATED FEEDS — *Con.*					
(*a*) *Protein* — Con.					
Rye feed,	11	11	2.36	1.08	1.60
Wheat middlings (flour),	44	10	3.06	1.01	1.65
Wheat middlings (standard),	103	10	2.88	1.28	2.06
Wheat mixed feed,	282	10	2.72	1.44	2.57
Wheat bran,	116	10	2.59	1.45	2.79
(*b*) *Starchy.*					
Ground barley,	1	13	1.56	0.34	0.66
Buckwheat hulls,	1	12	0.49	0.52	0.07
Cocoa dust,	1	7	2.30	0.63	1.34
Corn cobs,	8	8	0.52	0.63	0.06
Corn and cob meal,	29	11	1.38	0.46	0.56
Corn kernels,	13	11	1.82	0.40	0.70
Corn meal,	3	14	1.92	0.34	0.71
Corn and oat feed (Victor),	2	10	1.38	0.61	0.59
Corn, oat and barley feed (Schumachers),	1	8	1.80	0.63	0.83
Cotton hulls,	3	11	0.75	1.08	0.18
Hominy meal,	125	11	1.65	0.76	1.27
Common millet seed,	2	12	2.00	0.45	0.95
Japanese millet seed,	1	12	1.58	0.35	0.63
Molasses (Porto Rico),	1	24	0.51	3.68	0.12
Dried molasses beet pulp,	1	8	1.60	1.47	0.16
Oat kernels,	1	11	2.05	–	–
Oat feed,	14	7	1.26	0.75	0.48
Oat feed (low grade),	15	7	0.88	0.70	0.35
Peanut feed,	2	10	1.46	0.79	0.23
Peanut husks,	1	13	0.80	0.48	0.13
Louisiana rice bran,	1	11	1.42	0.83	1.70
Rye middlings,	1	11	1.87	0.82	1.28
Damaged wheat,	1	13	2.26	0.51	0.83
Wheat flour,	2	12	2.02	0.36	0.35
(*c*) *Poultry.*					
American poultry food,	1	8	2.22	0.52	0.98
Meat and bone meal,	10	6	5.92	–	14.68
Meat scraps,	4	9	7.63	–	8.11

TABLE II. — FERTILIZER INGREDIENTS OF FODDER ARTICLES — *Concluded.*

[Figures equal percentages or pounds in 100.]

Name.	Number of Analyses.	Water.	Nitrogen.	Potash.	Phosphoric Acid.
VI. DAIRY PRODUCTS.					
Whole milk,	297	86.4	0.57	0.19[1]	0.16
Human milk,	3	88.1	0.24	–	–
Skim milk,	22	90.3	0.59	0.18[2]	0.20
Butter milk,	1	91.1	0.51	0.05	0.04
Whey,	1	93.7	0.10	0.07	0.17
Butter,	117	12.5	0.19	–	–

[1] From Farrington and Woll. [2] From Woll's Handbook.

Table III. — Analyses of Dairy Products.

[Per Cent.]

Name.	Number of Analyses.	Solids.			Fat.			Proteids (N. × 6.25).	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	6,399[1]	19.55	10.02	13.55	10.70	1.50	4.49	3.52[2]	–	0.73[3]
Human milk,	3	13.59	10.50	11.87	3.77	1.66	2.52	1.48	–	0.24
Colostrum,	2	24.75	21.25	23.00	3.00	3.00	3.00	2.84[4]	–	1.00
Skim milk (largely from Cooley process),	359	10.48	7.68	9.20	1.80	0.05	0.32	–	–	–
Buttermilk,	31	9.86	6.83	8.33	0.38	0.11	0.27	–	–	–
Cream (from Cooley process),	203	32.78	18.12	26.10	25.00	10.53	17.60	–	–	–
Butter (salted),	189	94.84	82.55	86.95	89.33	75.94	82.65	1.11[5]	3.21	–
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	0.76	–	–

[1] Largely station herd, Jersey blood predominating. [2] Average of 961 samples. [3] Average of 388 samples. [4] Nitrogen. [5] Curd and natural ash.

TABLE IV. — COEFFICIENTS OF DIGESTIBILITY OF AMERICAN FODDER ARTICLES. EXPERIMENTS MADE IN THE UNITED STATES.[1]

J. B. LINDSEY AND P. H. SMITH.

EXPERIMENTS WITH RUMINANTS.
EXPERIMENTS WITH SWINE.
EXPERIMENTS WITH HORSES.
EXPERIMENTS WITH POULTRY.
EXPERIMENTS WITH CALVES.

Complete through Aug. 1, 1910.

EXPLANATION OF TABLE IV.

The first compilation of all digestion coefficients resulting from experiments made in the United States was made and published by J. B. Lindsey in 1896.[2] Jordon and Hall also published very complete data in 1900.[3] Since then the writer and his co-workers have revised and published similar tables in 1902[4] and 1906.[5] The present publication is intended to be complete to December, 1910.

By *coefficient of digestibility* is meant the percentage of the ingredients which the animal can actually digest. Thus, of the 6.3 pounds of total protein in 100 pounds of Timothy hay, experiments have shown that 48 per cent., or 3 pounds, are digestible. The figure 48 is the digestion coefficient. The average coefficients determined have been applied to the average fodder analyses in Table I., and have enabled us to calculate the average amount of each fodder constituent digestible.

[1] Being a portion of the report of the Department of Plant and Animal Chemistry.
[2] Ninth report of the Hatch Experiment Station, pp. 157-170.
[3] Bulletin 77, United States Department of Agriculture, Office of Experiment Stations.
[4] Fourteenth report of the Hatch Experiment Station, pp. 195-216.
[5] Eighteenth report of the Hatch Experiment Station, pp. 224-248.

Experiments with Ruminants.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. Green Fodders.									
(a) Meadow Grasses and Millets.									
Grass, native blue, Nevada (*Poa Sandbergii*),	1	2	52—53 53	– –	20—25 23	64—64 64	44—45 45	60—61 60	48—51 50
Grass, meadow, young,	1	1	69	–	–	65	74	72	55
Grass, meadow, young, dried,	1	1	71	–	–	71	77	73	60
Grass, timothy,	1	3	63—65 64	– –	31—33 32	48—48 48	54—58 56	65—67 66	52—54 52
Grass, timothy, rowen,	1	2	– –	65—67 66	– –	72—72 72	60—68 64	67—68 68	51—55 52
Grass, Western brome (*Bromus marginatus*),	1	2	60—60 60	– –	42—42 42	68—68 68	53—53 53	67—67 67	15—16 16
Barnyard millet in blossom (Massachusetts) (*Panicum crus-galli*).	3	6	67—76 70	– –	45—67 56	58—70 65	71—77 73	65—77 71	54—67 58
Japanese millet, bloom to early seed (Storrs),	2	3	– –	62—66 64	52—58 55	45—57 50	59—63 62	64—68 67	60—72 68
Hungarian grass, early to late bloom,	3	8	61—71 66	61—74 68	– –	59—72 63	65—76 70	64—71 67	48—85 62
(b) Cereal Fodders.									
Barley fodder, bloom,	2	4	– –	62—71 67	– –	69—73 72	49—66 61	69—76 71	56—63 60
Barley fodder, seeds forming,	2	2	– –	66—71 68	40—44 42	67—71 69	47—65 56	– 74	48—50 49
Corn fodder, dent, immature,	5	14	64—74 68	– –	42—43 42	56—80 66	56—76 65	64—79 71	37—83 86

Corn fodder, dent, milk, average,	7	17	70	–	39[1]	62	64	77	76
Corn fodder, dent, mature, average,	12	23	69	72[2]	34	54	59	75	75
Corn fodder, dent, mature, B. & W., coarse,	1	2	51—54 52	– –	– –	20—28 24	46—47 46	57—61 59	74—82 78
Corn fodder, dent, brewers, milk,	1	2	71—73 72	– –	44—49 46	68—69 69	67—71 69	76—77 77	67—70 68
Corn fodder, dent, early Mastodon, milk,	1	2	72—72 72	– –	33—38 36	56—58 57	60—60 60	79—79 79	80—81 81
Corn fodder, Eureka silage, ears just forming,	1	3	64—69 67	– –	42—43 42	67—68 67	56—61 60	70—74 72	65—67 66
Corn fodder, dent, Leaming, milk,	1	2	69—71 70	– –	34—40 36	60—60 60	60—63 61	76—77 77	75—77 76
Corn fodder, dent, Pride of the North, mature,	2	4	69—81 74	– –	29—40 35	59—68 63	58—74 66	76—86 81	74—78 80
Corn fodder, dent, Rustler's white, mature,	1	2	69—70 70	– –	25—30 28	40—45 43	57—61 59	77—79 78	75—78 76
Corn fodder, dent, Wing's improved white cap, milk,	1	2	70—71 70	– –	38—40 39	62—64 63	62—68 65	76—76 76	69—71 70
Corn fodder, flint, Sanford, mature,	2	4	63—73 69	67—75 71	14—50 34	46—57 52	67—80 75	67—75 71	53—74 66
Corn fodder, sweet, milk stage,	1	2	77—78 77	– –	– –	77—78 77	74—76 75	80—81 81	73—74 74
Corn fodder, sweet, roasting stage,	9	12	– –	67—79 72	22—61 48	52—69 62	54—72 60	73—82 77	62—82 74
Oat fodder, bloom to early seeding,	3	5	– –	56—65 62	49—68 60	68—76 73	43—63 55	60—67 62	67—72 69
Rye fodder, heading,	1	2	73—74 74	– –	– –	79—80 79	80—80 80	70—71 71	74—74 74
Sorghum fodder, blossom,	1	2	73—73 73	– –	– –	51—56 53	74—75 75	78—78 78	81—82 81

[1] Average eight trials.

[2] Average seventeen trials.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. GREEN FODDERS — *Con.*									
(*b*) *Cereal Fodders* — Con.									
Sorghum fodder, Early Amber, past blossom,	2	4	61—69 65	- -	40—43 42	38—51 44	42—72 55	70—74 73	60—67 64
Sorghum fodder, average,	3	6	68	-	42	47	62	75	70
(*c*) *Legumes.*									
Alfalfa, fodder,	1	2	61—61 61	- -	40—40 40	73—75 74	42—43 43	71—72 72	38—39 39
Soy beans, variety uncertain, before bloom,	1	2	- -	64—67 66	- -	77—80 79	45—55 50	71—73 72	50—58 54
Soy beans, variety uncertain, seeding,	1	2	- -	61—63 62	- -	68—71 69	38—43 41	72—75 73	49—59 54
Soy beans, medium green, full blossom,	1	2	- -	62—63 63	22—28 25	76—78 77	45—49 47	69—73 71	46—54 50
Soy beans, medium green, seeding,	4	12	62—69 65	65—69 67	16—45 28	74—84 78	31—53 45	71—81 77	31—69 55
Clover, crimson, late blossom,	1	3	- -	68—70 69	- -	77—77 77	54—58 56	74—75 74	63—69 66
Clover, red, late blossom,	1	2	65—67 66	- -	- -	66—68 67	52—53 53	76—79 78	63—66 65
Clover, rowen, late blossom,	1	2	- -	60—62 61	- -	61—62 62	51—54 52	64—68 65	60—61 61
Clover, average two samples,	2	4	65—67 66	60—62 61	- -	61—68 65	51—54 53	64—79 72	60—66 63
Cow peas, ready for soiling,	2	4	66—77 68	72—76 74	19—28 23	73—77 76	57—62 60	76—84 81	56—62 59

Little Lupine (*Lupinus Sp.*),	1	2	62—74 68	– –	65—69 67	73—77 75	46—65 56	67—84 76	42—72 57
Canada field peas, before bloom,	1	2	68 –	71—72 71	– –	81—83 82	62—62 62	71—71 71	50—55 52
Canada field peas, bloom to seeding,	2	6	60—67 64	– –	26—45 37	79—83 81	40—52 45	72—80 76	45—64 55
Spring vetch (*Vicia sativa*),	1	2	62—62 62	– –	– 17	71—72 72	42—46 44	75—77 76	57—60 59
Winter or hairy vetch (*Vicia villosa*), bloom,	4	14	66—78 71	– –	29—55 42	79—88 83	52—73 63	68—84 77	63—82 71
(*d*) *Mixed and Miscellaneous.*									
Apple pomace,	2	6	66—80 72	– –	24—63 49	– –	36—85 65	80—90 85	39—52 46
Balsam root or big sunflower (*Balsamorhiza sagittata*),	1	2	66—66 66	– –	34—42 38	76—79 78	57—61 59	74—76 75	74—75 74
Barley and peas, bloom,	3	4	– –	55—71 65	52—55 54	73—81 75	38—61 52	56—76 68	54—65 59
Bitter brush (*Kunzia tridentata*),	1	2	75—79 77	– –	48—69 59	79—85 82	56—83 70	86—87 87	70—73 71
Wild carrot (*Septotaenia multifida*),	1	2	68—69 69	– –	52—54 53	70—72 71	43—52 47	82—84 83	81—82 82
Wild dandelion (*Crepis intermedia*),	1	2	62—63 63	– –	58—60 59	61—65 63	34—37 36	77—78 78	31—35 33
Thousand headed kale (*Brassica oleracea*),	2	4	66—71 68	– –	37—45 39	78—83 81	55—64 59	74—77 76	61—72 66
Oats and spring vetch, bloom,	1	3	65—69 67	– –	49—55 53	73—76 75	65—72 68	66—70 68	42—52 47
Oats and peas, bloom,	2	5	69—72 70	67—69 68	45—52 49	68—82 74	54—70 64	66—77 72	51—74 64
Oats and peas, partly seeded,	3	5	– –	58—70 62	36—63 47	68—83 74	48—67 55	56—67 63	55—74 64

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
I. GREEN FODDERS — *Con.*									
(*d*) *Mixed and Miscellaneous* — Con.									
Prickly pear (*Opuntia lindheimeri*),	1	2	65—67 66	71—77 74	34—37 36	57—59 58	41—41 41	82—83 83	67—68 68
Prickly pear (*Opuntia lævis?*),	1	2	62—65 64	70—73 71	33—38 36	39—42 41	51—56 54	78—80 79	69—69 69
Prickly pear (*Opuntia engelmannii cycloides*),	2	4	57—70 65	63—75 71	39—44 42	– –	30—45 39	77—83 81	74—88 83
Mountain Indian Pink or Painted Cup (*Castilleia miniata* var.).	1	2	66—68 67	– –	46—47 47	63—66 65	48—50 49	79—81 80	75—78 77
Indian potato (*Atænia Gairdneii*),	1	2	66—67 67	– –	50—50 50	54—59 57	73—75 74	64—66 65	76—78 77
Dwarf Essex rape, first growth,	1	2	88—88 88	– –	76—77 76	90—91 90	90—90 90	94—94 94	54—55 54
Dwarf Essex rape, second growth,	1	2	81 –	– –	47—51 49	86—89 87	84—84 84	90—91 90	42—44 43
Dwarf Essex rape, average,	2	4	85	–	63	89	87	92	48
Common sunflower, Nevada (*Wyethia mollis*),	1	2	60—62 61	– –	53—53 53	69—70 69	54—55 54	59—63 61	62—64 63
Winter wheat and hairy vetch,	2	5	68—71 69	– –	40—46 44	69—78 75	66—71 68	71—76 73	54—61 57
II. SILAGE.									
Soy bean silage, goats,	1	2	52—66 59	– –	– –	71—80 76	47—62 55	46—58 52	66—77 72
Soy bean silage, steers,	1	2	50—50 50	– –	– –	54—56 55	42—44 43	61—61 61	47—52 49

Soy bean silage, mammoth yellow, bloom,	1	3	52—65 58	63—73 67	- -	57—69 61	51—67 59	74—80 76	48—60 52
Soy bean silage, average,	3	7	56	67	-	66	53	65	57
Soy bean and barnyard millet silage,	1	4	54—65 59	- -	- -	55—62 57	61—73 69	54—63 59	69—75 72
Soy bean and corn silage (9 pints beans, 14 pints corn),	4	8	62—73 69	71—75 72	39—48 42	54—68 63	51—73 63	73—81 78	67—91 83
Clover silage,	2	5	32—52 44	36—54 45	26—51 36	22—40 35	41—55 48	31—56 45	36—60 45
Corn silage, dent, immature, average all trials,	7	17	59—68 64	60—68 64	31—35 33	42—65 53	54—78 68	60—70 66	61—85 71
Corn silage, dent, mature, average all trials,	10	27	57—76 66	60—77 70[1]	24—54 38	21—69 51	45—80 65	63—83 71	65—90 82
Corn silage, dent, Leaming, immature,	2	4	59—66 62	60—68 64	31—35 33	46—51 49	54—71 63	62—66 65	61—77 72
Corn silage, dent, Leaming, mature,	1	2	68—72 70	- -	46—54 50	59—69 64	68—74 71	71—74 73	83—86 85
Corn silage, dent, Pride of the North, mature,	1	2	72—76 74	- -	24—28 26	- 45	72—73 73	81—83 82	72—82 77
Corn silage, dent, Virginia, mature,	1	4	57—74 64	60—75 66	- -	21—55 39	51—69 58	66—79 72	65—84 77
Corn silage, Sanford, ears glazing,	1	2	74—76 75	76—77 77	47—48 48	54—54 54	77—78 78	78—80 79	76—78 77
Corn silage, dent, average all trials,	17	48	64	70[1]	38	50	65	69	77
Corn silage, flint, mature, small varieties,	4	11	68—78 75	66—80 77	- -	48—73 65	75—79 77	71—83 79	- 82
Corn silage, flint, large white. partly eared,	1	2	69—70 70	72—73 72	31—37 34	56—56 56	72—72 72	75—76 76	72—74 73
Corn silage, fine crushed, steers,	1	2	60—68 64	- -	- -	32—44 38	72—78 75	60—70 65	75—77 76

[1] Average twenty-five trials.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
II. SILAGE — *Con.*									
Corn silage, fine crushed, sheep,	1	2	51—56 54	- -	- -	21—22 21	59—68 64	53—57 55	67—69 68
Corn silage, mature, fed raw,	1	1	-	-	-	45	59	71	86
Corn silage, mature, cooked,	1	1	-	-	-	39	70	75	87
Corn silage, steamed,	1	2	73—74 73	75—76 76	46—50 48	53—57 55	75—76 76	75—77 76	90—90 90
Corn silage, variety unknown,	1	2	- -	- -	- -	55—58 57	68—68 68	78—78 78	66—67 66
Corn silage, variety unknown, raw,	1	2	71—73 72	- -	40—45 43	54—63 59	72—75 74	74—76 75	90—90 90
Corn silage, variety unknown, steamed,	1	2	60—62 61	- -	5—13 9	5—6 5	62—64 63	70—72 71	79—80 79
Corn silage, sweet, mature,	1	2	67—70 68	68—72 70	- -	53—55 54	68—74 71	71—73 72	82—85 83
Kaffir corn silage, well matured,	1	3	54—56 55	56—59 57	- -	22—23 28	57—59 57	59—62 62	47—54 50
Oat and pea silage,	1	2	63—68 65	63—70 67	52—53 52	74—75 75	58—65 61	64—70 67	73—77 75
Cow pea silage,	1	4	59—60 60	- -	- -	57—58 57	50—54 52	72—73 72	62—64 63
Sorghum silage, well matured,	1	3	51—60 57	53—62 59	- -	6—13 9	51—63 58	59—67 64	53—60 56
Silage, mixture of corn, sunflower heads and horse beans,[1]	1	2	64—68 66	66—70 68	40—41 41	60—65 63	56—64 60	71—74 72	75—78 77

Silage, mixture of corn, sunflowers (whole plant) and horse beans.[1]	1	2	64—67 65	68—71 69	20—31 26	57—59 58	63—68 65	72—75 74	72—76 74
Vetch silage, raw,	1	2	62—64 63	– –	46—48 47	56—57 56	61—64 63	66—68 67	76—79 77
Vetch silage, steamed,	1	2	50—53 51	– –	35—40 38	13—16 15	50—53 51	61—64 63	63—63 63
III. HAY AND DRY COARSE FODDERS.									
(a) Meadow Grasses and Millets.									
Kentucky blue grass (*Poa pratensis*),	2	7	56[2] –	– –	9—42 23	47—63 57	63—74 66	53—69 61	43—62 52
Canada blue grass (*Poa compressa*), bloom,	1	2	62—63 62	– –	42—42 42	43—44 43	70—71 71	63—63 63	36—39 37
Blue-joint, bloom,	1	2	67—70 69	68—71 70	– –	68—72 70	71—73 72	66—71 69	51—53 52
Blue-joint, past bloom,	1	1	40	42	–	57	37	43	37
Bromus inermis hay,	2	4	– –	– –	– –	45—52 50	55—61 59	66—70 68	17—31 24
Buffalo grass (*Bulbilis Dactyloides*),	1	1	55	–	6	54	65	62	62
Chess or cheat (*Bromus secalinus*),	1	1	45	–	23	42	46	49	32
Colorado upland hay (largely *Agropyrum tenerum*),	2	6	47—63 56	45—59 52	40—48 43	58—67 62	54—63 59	49—66 57	16—53 34
Cord grass (*Spartina Cynoswroides* L.),	1	6	– –	– –	16—38 23	34—42 39	54—58 56	46—52 49	47—55 50
Crab grass (*Eragrostis Neo Mexicana*), ripe,	3	8	47—57 53	– –	29—52 43	30—56 58	50—66 60	50—59 53	30—52 43
Dakota lowland prairie hay,	1	2	– –	– –	– –	41—44 43	59—61 60	56—57 57	40—40 40
Dakota upland prairie hay,	1	6	– –	– –	5—17 11	28—40 32	45—61 53	44—55 51	25—84 32

[1] Proportion of one acre corn, one-fourth acre sunflower heads and one-half acre horse beans.

[2] One trial.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY AND DRY COARSE FODDERS — *Con.*									
(*a*) *Meadow Grasses and Millets* — Con.									
Meadow fescue (*Festuca elatior pratensis*), bloom,	1	2	60—61 61	– –	– 46	51—53 52	– 67	58—60 59	53—54 54
Johnson grass (*Andropogon halepensis*),	2	3	57	–	–	40	68	57	38
Millets. Barnyard millet, well headed,	1	3	57—58 57	– –	63—64 63	63—64 64	60—64 62	50—52 52	44—50 46
Millets. Barnyard millet, just heading out,	1	2	59—62 61	– –	51—52 52	56—59 58	66—71 69	55—59 57	47—49 48
Millets. Cat-tail millet (*Pennisetum spicatum*),	1	2	61—64 62	– –	– –	61—65 63	65—68 67	58—60 59	45—48 46
Millets. Golden millet,	1	1	54	–	31	23	56	58	49
Millets. Hungarian,	1	2	64—66 65	66—67 66	– –	– 60	67—68 68	67—67 67	– 64
Millets. Millet (*Chætochloa Italica*),	1	2	52—58 56	– –	16—32 24	30—32 31	60—66 63	52—59 56	48—52 50
Mixed grasses, rich in protein (8 to 10 per cent.),	21	73	54—69 61	60—66 62[1]	37—53 47	34—65 57	49—78 62	56—68 62	26—58 50
Mixed grasses, timothy predominating,	5	10	49—59 55	51—61 58	16—36 30	37—54 47	46—50 65	56—66 59	39—57 45
Meadow, swale or swamp hay,	1	2	38—40 39	– –	– –	31—37 34	30—36 33	– 46	– 44
Nevada native hay, second growth, mixed grasses,	1	2	75—77 76	– –	62—63 63	71—72 71	77—79 78	76—79 77	78—80 79

Nevada native hay, half clover,	1	2	65—67 66	– –	44—44 44	51—53 52	66—67 66	70—72 71	61—62 62
Nevada native hay, largely Buckley's blue grass,	1	2	64—65 65	– –	44—45 45	46—47 47	—66 66	68—69 69	68—71 70
Nevada native hay, largely timothy and tickle grass,	1	2	73—75 74	– –	57—61 59	64—64 64	71—77 74	78—79 79	70—74 72
Nevada native hay, largely wire grass and brown top sedge,	1	2	64—67 66	– –	50—52 51	48—49 49	75—77 76	58—64 61	70—71 71
Tall oat grass (*Arrhenatherum elatius*), late bloom,	1	2	54—57 55	– –	39—43 41	– 51	53—57 55	56—59 58	54—58 56
Wild oat grass (*Danthonia spicata*),	2	3	60—68 64	61—69 65	– –	49—68 58	65—71 68	62—69 65	36—63 50
Orchard grass, ten days after bloom,	1	1	54	56	–	59	58	54	54
Orchard grass, stage not given,	1	2	57—60 59	– –	– –	60—60 60	60—67 64	55—57 56	55—57 56
Orchard grass, average both samples,	2	3	56	56	–	60	61	55	55
Pasture grass,	1	3	73	73	52	73	76	74	67
Prairie grass (*Sporobolus Asper*),	1	1	56	–	25	18	61	61	57
Red top,	2	3	58—62 60	59—64 61	– –	60—62 61	61—62 61	59—65 62	44—59 51
Rowen, mixed grasses,	3	12	– –	63—68 65	– –	– 70	62—72 66	60—69 65	44—51 47
Rowen, chiefly timothy,	1	4	– –	62—67 64	– –	66—69 68	62—73 66	60—65 63	48—51 49
Rowen, average all trials,	4	16	-	65	–	69	66	64	47

[1] Average sixty trials.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY AND DRY COARSE FODDERS — *Con.*									
(*a*) *Meadow Grasses and Millets* — Con.									
Salt hays. Black grass (*Juncus Geradi*),	2	5	50—62 56	– –	67—71 69	53—63 58	50—66 59	46—59 52	37—51 44
Salt hays. Branch grass (*Distichlis spicata*),	2	5	49—57 52	– –	– 58	– 56	48—57 54	45—55 49	27—42 35
Salt hays. Flat sage (*Spartina stricta maritima* var.),	1	3	55—58 57	– –	61—62 62	50—55 52	60—61 60	54—57 55	33—40 36
Salt hays. Fox grass (*Spartina patens*),	3	7	51—56 54	– –	57—59 58	56—63 60	46—60 53	51—55 53	17—51 36
Salt hays. Salt hay mixture, fox and branch grasses, etc.,	1	2	52—56 54	– –	68—70 69	41—43 42	54—61 58	51—54 52	26—30 28
Slough grass hay, Dakota,	1	6	– –	– –	20—31 24	36—46 42	54—68 59	49—65 55	44—68 54
Timothy, in bloom,	4	8	54—66 59	51—67 58	33—34 34	50—60 57	50—62 57	57—72 63	26—62 48
Timothy, past bloom,	8	17	47—61 52	43—62 52	30—68 59	32—50 43	32—57 46	53—70 59	23—70 51
Timothy, stage unknown,	1	4	57—62 59	57—62 59	47—54 50	38—41 40	– –	– –	– –
Timothy, average all trials,	24	58	55	56	39	48	50	62	50
Timothy fed with cottonseed meal (16 hay, 1 meal),	1	2	52—56 54	– –	17—28 22	24—32 28	46—52 49	61—63 62	36—37 36
Timothy fed with cottonseed meal (12 hay, 1 meal),	1	2	49—55 52	– –	9—30 20	27—38 32	43—51 47	58—62 60	52—54 53

Timothy fed with cottonseed meal (8 hay, 1 meal),	1	2	44—48 46	- -	3—10 6	18—23 21	40—44 42	53—56 54	42—45 44
Timothy fed with cottonseed meal (4 hay, 1 meal),	1	2	45—46 46	- -	- -	4—4 4	42—43 43	56—75 67	44—66 55
Timothy fed with cottonseed meal (2 hay, 1 meal),	1	2	48—56 52	- -	- 13	- 13	34—44 39	65—71 68	72—74 73
Timothy fed with cottonseed meal (1 hay, 1 meal),	1	2	47—52 49	- -	19—23 21	- -	24—26 25	68—78 73	79—87 83
Timothy fed with cottonseed meal, average all trials,	6	12	50	-	16	20	41	62	57
Timothy and clover, poorly cured,	1	2	54—55 55	- -	- -	37—38 38	52—54 53	- 60	- 58
Timothy and red top, late bloom,	1	7	48—60 54	- -	11—24 19	35—43 39	49—63 55	55—66 60	28—51 42
Western wheat grass (*agropyrum glaucum occidentale*),	1	6	- -	- -	2—30 14	42—61 51	62—74 68	55—69 61	31—49 39
Wyoming native hay, wire grass,	2	5	51—64 57	- -	31—55 42	33—60 47	56—66 61	53—65 56	53—63 58
Wyoming native hay, wheat grass,	4	9	61—67 64	- -	28—54 40	53—62 57	63—74 68	63—70 66	38—54 47
Witch grass (Triticum repens),	2	4	60—63 61	61—64 62	- -	49—64 58	56—68 62	62—70 66	54—60 57
(*b*) *Cereal Fodders.*									
Barley hay,	1	4	59	62	-	65	62	63	41
Corn fodder, dent, immature, average all trials,	6	15	51—70 62	51—71 63	39—47 43	20—67 50	45—77 67	55—70 62	44—84 65
Corn fodder, dent, immature, B. & W.,	1	4	51—64 57	- -	- -	20—36 27	45—74 59	57—66 61	66—84 76
Corn fodder, dent, in milk,	5	11	59—66 63	- -	- -	44—51 50	50—71 64	61—69 66	67—79 75
Corn fodder, dent, mature,	10	30	57—70 66	- -	16—30 23	30—61 45	43—73 63	61—81 73	56—82 70

EXPERIMENTS WITH RUMINANTS — *Continued.*

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY DRY AND COARSE FODDERS — *Con.*									
(*b*) *Cereal Fodders* — Con.									
Corn fodder, flint, ears forming,	1	3	69—72 70	71—73 71	- -	69—73 70	72—73 72	71—73 71	63—71 67
Corn fodder, flint, mature,	5	11	63—73 70	- -	- -	56—79 64	69—80 76	63—78 71	59—79 71
Corn fodder, sweet, mature,	3	6	60—71 67	62—74 70	- -	54—73 64	70—77 74	57—73 68	63—71 74
Corn stover, dent, Pride of the North,	1	2	53—55 54	- -	29—33 31	45—45 45	58—63 61	53—55 54	63—66 65
Corn stover, Eureka silage, ears just forming,	2	4	54—64 59	- -	40—46 43	57—58 53	56—72 65	53—64 59	62—67 65
Corn stover, average all trials,	12	33	53—64 57	49—58 55	29—46 41	11—58 37	52—74 64	53—64 59	36—77 69
Corn stover, below ear,	1	2	64—69 67	- -	- -	15—27 21	71—75 74	65—73 69	79—80 80
Corn stover, above ear,	1	2	52—58 55	- -	- -	17—27 22	69—72 71	50—57 54	62—65 64
Corn stover, minus pith (by hand),	1	3	54—57 55	55—59 57	- -	16—28 20	60—65 63	55—58 57	70—75 72
Corn stover, minus pith, ground (Marsden's process),	1	3	63—64 63	- -	46—55 49	57—62 60	60—61 61	65—66 66	82—83 83
Corn stover minus pith, ground (Marsden's process), steamed,	1	3	51—59 59	- -	47—55 50	59—60 60	37—54 48	57—62 59	70—85 80
Corn stover, minus pith, average,	3	9	51—64 58	55—59 57	46—55 50	16—62 47	37—65 57	55—66 61	70—85 78

Corn stover, blades and husks,	1	4	60—68 65	– –	15—35 23	41—55 48	67—76 73	64—71 66	53—64 58
Corn stover, tops and blades,	1	2	59—60 60	– –	– –	54—57 55	71—72 71	62—63 62	71—72 71
Corn stover, leaves,	1	2	55—56 56	– –	– –	43—69 56	54—67 61	57—61 59	61—65 63
Corn stover, leaves,	1	2	62—67 65	– –	– –	28—41 35	75—80 78	66—70 68	52—59 56
Corn stover, leaves, average both trials,	2	4	55—67 61	– –	– –	28—69 46	54—80 70	57—70 64	52—65 60
Corn stover, husks,	1	2	71—73 72	– –	– –	24—35 30	78—81 80	– 75	23—42 33
Kaffir corn fodder,	1	4	59—62 61	– –	5—11 8	34—42 38	56—63 60	64—68 66	57—67 61
Kaffir corn stover, shredded,	1	4	54—58 56	– –	13—26 19	29—34 30	65—69 67	56—60 58	77—81 79
Kaffir corn stover,	1	1	63	–	43	50	67	67	60
Kaffir corn stover, average both trials,	2	5	57	–	24	34	67	60	75
Oat hay, bloom to milk,	2	6	51—59 55	50—61 55	35—54 45	47—66 57	54—71 58	47—58 53	44—65 53
Oat hay, milk to dough,	4	14	48—60 54	48—61 54	20—54 37	34—60 52	39—62 48	49—62 56	52—72 64
Oat hay, average all trials,	6	20	54	54	39	53	51	55	60
Oat straw,	4	12	42—61 54	51—53 52	21—62 38	3—36 21	34—76 61	43—64 55	24—58 42
Sorghum fodder, Minnesota Early Amber,	1	3	58—60 58	54—55 54	41—49 44	40—47 43	42—56 49	57—67 61	62—67 65
Sorghum fodder, variety unknown,	1	6	– –	– –	9—55 23	30—74 53	57—84 71	49—82 64	66—87 77

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY AND DRY COARSE FODDERS — *Con.*									
(*b*) *Cereal Fodders* — Con.									
Sorghum fodder, leaves,	1	2	60—66 63	– –	– –	59—62 61	65—76 70	62—67 65	46—47 47
Sorghum fodder, bagasse,	1	1	61	–	–	14	64	65	46
(*c*) *Legumes.*									
Alfalfa, first crop,	19	33	55—72 63	– –	34—67 54	61—85 75	19—65 47	61—79 72	23—65 43
Alfalfa, second crop,	13	27	54—67 63	– –	35—59 52	64—81 77	40—53 46	65—80 74	14—51 42
Alfalfa, third crop,	1	2	56—60 58	– –	40—49 44	68—70 69	28—40 34	71—71 71	38—45 42
Alfalfa, poor quality,	1	2	56—56 56	58—58 58	35—44 39	66—66 66	38—43 40	68—72 70	31—45 38
Alfalfa, stage of cutting unknown,	1	2	54—55 55	– –	24—25 25	67—70 69	40—42 41	68—70 69	13—19 16
Alfalfa, stage of cutting unknown,	1	6	– –	– –	31—40 35	74—80 78	40—50 44	65—77 72	33—42 37
Alfalfa, average all trials,	42	80	62	–	50	74	46	72	40
Soy bean,	1	2	62—63 62	– –	– –	70—72 71	59—62 61	66—71 69	19—40 29
Clover, alsike, full to late bloom,	4	9	55—64 59	56—65 60	– 42	64—71 66	40—59 50	59—74 66	21—69 38
Clover, crimson,	3	9	57—65 62	52—58 56	– –	64—73 69	32—58 45	52—74 62	29—54 44

Clover, red, bud to early blossom,	1	2	63—64 64	– –	59—61 60	64—64 64	57—62 59	67—68 68	52—52 52
Clover, red, full blossom,	1	2	58—61 60	– –	54—58 56	59—61 60	43—49 46	68—71 69	55—56 55
Clover, red, stage of cutting not given,	10	21	49—67 58	51—66 55	0—44 32	47—69 57	42—70 54	56—72 65	40—70 56
Clover, red, average all trials,	12	25	58	55	36	58	54	65	56
Clover, white,	1	1	66	67	–	73	61	70	51
Clover, rowen,	2	4	– –	58—60 59	42—50 46	60—69 65	45—51 47	62—64 63	58—60 60
Sweet clover,	1	3	58—62 61	– –	65—67 66	75—76 75	27—37 34	71—73 72	28—33 31
Pea straw,	1	3	65—69 67	– –	27—37 33	76—80 78	48—54 51	78—80 79	47—51 50
Cow pea,	1	2	– 59	– –	– –	64—65 65	41—45 43	– 71	46—54 50
Peanut vine,	1	2	59—60 60	– –	– –	63—64 63	51—53 52	69—70 70	62—70 66
French pea (*Lathyrus* ——),	1	2	67—68 68	– –	65—69 67	81—82 82	49—50 49	75—76 75	58—60 59
Spring vetch (*Vicia sativa*),	2	4	64—67 66	66—68 67	52—60 56	61—71 66	54—61 58	70—72 72	68—72 70
Winter or hairy vetch (*Vicia villosa*),	2	8	59—71 67	– –	34—67 47	68—83 82	51—63 58	62—75 67	53—74 67
(*d*) *Mixed and Miscellaneous.*									
Buttercups (*Ranunculus acris*),	1	2	56	57	–	56	41	67	70
Cottonseed feed (4-1),[1] sheep,	2	6	54—60 56	– –	23—25 28	36—45 41	51—60 56	57—60 59	86—94 91
Cottonseed feed (4-1), steers,	1	2	54	–	46	54	45	58	85

[1] Four hulls to one meal.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
III. HAY AND DRY COARSE FODDERS — *Con.*									
(*d*) *Mixed and Miscellaneous* — Con.									
Cottonseed feed, average both (4-1) trials,	3	8	56	-	33	44	53	59	90
Cottonseed feed (5—1) steers,	2	5	42—60 49	- -	20—46 31	32—54 42	28—54 50	50—67 60	83—94 88
Cottonseed feed (7—1) and (6—1), steers,	1	3	45—46 46	- -	- 28	44—46 45	34—40 37	50—51 50	81—82 82
Cottonseed feed (3-1) to (2-1), steers,	2	9	54	-	32	64	47	54	85
Cottonseed feed, average all trials,	8	25	53	-	31	51	47	56	87
Cottonseed hulls,	4	13	35—47 41	- -	- -	0—25 6	.5—58 47	13—46 34	58—89 79
Oats and peas,	2	7	56—67 61	56—67 60	54—65 58	69—78 73	50—64 58	54—66 61	51—69 59
Oats and sand vetch,	1	2	55—55 55	56—56 56	43—46 44	64—66 65	48—50 49	58—59 59	58—67 63
Oats and spring vetch,	2	5	57—63 59	- 60	- 60	60—71 65	47—67 57	34—65 59	17—76 52
Oats and vetch, average,	3	7	58	58	56	65	55	59	55
Salt bush (*Atriplex Argentea*),	1	3	46—47 46	31—32 31	71—72 72	65—68 66	3—15 8	46—51 49	50—55 52
Wheat and sand vetch, blossom,	2	6	64—69 66	- -	33—60 47	70—77 74	63—66 65	67—71 68	62—67 64
White weed (*Leucanthemum vulgare*),	1	2	58	58	-	58	46	67	62
Willows (*Salix exigna*),	1	2	50—58 54	- -	24—40 32	20—38 29	40—44 42	63—70 67	73—67 70

IV. Roots and Tubers.									
Sugar beets,	1	2	94—95 95	98—100 99	- -	90—93 91	88—113 100	100—100 100	40—53 50
Mangolds,	1	2	77—80 79	83—87 85	- -	70—80 75	27—59 43	91—92 91	- -
Potatoes,	1	3	73—80 77	75—81 78	- -	43—45 44	- -	87—93 91	- 13
Ruta-bagas,	1	2	84—90 87	89—93 91	- -	75—86 80	61—87 74	94—95 95	77—92 84
English flat turnips,	1	2	91—95 93	93—99 96	- -	84—95 90	89—117 100	96—97 97	82—92 88
V. Concentrated Feedstuffs.									
(a) Protein.									
Soy bean meal, variety unknown,	2	3	75—79 78	- -	- -	89—91 90	0—73 33	68—73 71	81—98 89
Soy bean meal, medium green, coarse ground,	2	4	81—98 90	- -	42—77 57	88—95 91	- -	61—100 81	89—97 93
Bibby's dairy cake,	2	6	61—81 70	- -	18—44 33	58—76 66	1—68 46	71—88 81	84—99 92
Bile's Union Grains,	2	3	72—94 81	- -	22—70 39	69—86 76	78—118 93	75—98 86	95—102 98
Blood meal, Armour's,	1	2	- -	- -	- -	80—88 84	- -	- -	- -
Brewers' dried grains,	2	5	56—62 62	- -	- -	78—84 81	28—62 49	51—60 57	87—93 89
Buckwheat middlings,	1	3	71—79 75	- -	26—41 36	83—86 85	8—26 17	79—87 83	87—92 89
Buffalo Creamery Feed,	1	2	68—71 69	- -	20—25 23	80—82 81	52—57 55	70—72 71	83—91 87
Chapins Alfalfa Meal, a dairy feed,	1	2	52—67 59	- -	13—40 26	67—75 71	31—58 45	56—70 63	76—92 84

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. CONCENTRATED FEEDSTUFFS — *Con.*									
(*a*) *Proteins* — Con.									
Cottonseed, raw,	1	2	63—69 66	- -	- -	66—70 68	65—86 76	49—50 50	- 87
Cottonseed, roasted,	1	2	53—58 56	- -	- -	44—50 47	62—69 66	50—53 51	68—75 72
Cottonseed meal,	4	12	67—90 79	81—95 88	- 84[1]	76—96 84	26—55 35	66—96 78	87—100 94
Cottonseed meal, high grade (Maine),	1	2	90	95	-	83	-	96	100
Cottonseed meal, medium grade (Maine),	1	2	67—79 73	73—83 78	- -	81—86 84	40—47 44	73—91 82	95—95 95
Cottonseed meal, low grade (Maine),	1	2	60—63 62	62—67 65	- -	72—73 73	30—45 38	66—70 68	87—93 90
Cottonseed meal, low grade (Massachusetts),	1	2	60—76 68	- -	80—89 85	77—80 78	- 40	73—83 78	100—100 100
Cottonseed meal, high grade, dark colored, slightly fermented (Maine).	1	2	81—91 86	85—95 90	- -	82—83 83	- -	90—100 95	95—100 98
Dairy feed, H-O,	2	4	65—65 65	- -	- -	68—80 76	14—43 35	67—75 72	83—88 84
Distillers' dried grains, largely from rye,	1	2	56—59 58	- -	- -	56—63 59	- -	61—73 67	80—88 84
Distillers' dried grains, largely from corn,	8	17	70—89 79	- -	- -	66—80 73	59—100+ 95	69—97 81	88—98 95
Germ oil meal,	2	5	72—83 76	- 75	- -	65—77 73	- -	68—82 76	95—98 96

Gluten feed,	10	18	85—98 88	92—93 93[2]	78—99 88[3]	69—93 85	64—100+ 87	83—97 90	60—83 81
Gluten meal,	4	8	75—95 87	– –	– –	86—93 88	- –	78—94 88	91—99 93
Linseed meal, old process,	1	3	75—82 79	– –	– –	86—93 89	38—71 57	76—79 78	85—92 89
Linseed meal, new process,	1	3	73—83 78	– –	– –	82—88 85	49—100 74	82—87 84	90—98 93
Linseed meal, new process, Cleveland flax,	3	9	76—88 83	– 79	– –	– 83	– –	– 79	– 87
Linseed meal, new process, average,	4	12	82	79	–	84	74	80	89
Malt sprouts,	1	1	67	68	–	80	34	69	100
Malt sprouts (Massachusetts),	1	3	75—89 82	– –	3—33 19	74—77 76	98—100 99	76—91 85	74—100 87
Maize feed (Chicago),	1	2	83—85 84	– –	– –	83—84 84	68—76 72	84—87 85	90—90 90
Oat middlings, fine,	1	2	88—91 90	– –	31—40 36	80—81 81	21—77 49	94—97 96	93—94 94
Pea meal,	1	2	85—88 87	86—89 88	– –	80—86 83	25—26 26	93—94 94	52—57 55
Protena Dairy Feed,	1	2	63—66 65	– –	33—37 35	70—73 72	33—45 39	72—76 74	97—99 98
Cow pea meal,	1	2	85—88 87	– –	22—45 33	80—85 82	62—66 64	92—94 93	74—74 74
Rye feed, bran and middlings,	1	3	77—83 82	– –	25—48 35	78—82 80	– –	86—89 88	79—99 90
Unicorn Dairy Ration,	2	3	81—87 83	– –	6—40 25	73—77 76	62—84 72	86—94 89	95—96 96

[1] One trial. [2] Average thirteen trials. [3] Average two trials.

EXPERIMENTS WITH RUMINANTS — *Continued.*

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. CONCENTRATED FEEDSTUFFS — *Con.*									
(*a*) *Protein* — Con.									
Wheat bran, spring,	3	7	62—70 67	69—74 71	20—32 25	74—82 76	22—76 44	70—80 74	38—83 63
Wheat bran, winter,	1	3	57—66 62	– –	– –	75—79 77	– 27	62—76 65	51—80 64
Wheat bran, average all trials,	4	10	66	–	–	77	39	71	63
Wheat feed flour,	1	2	67—67 67	70—70 70	– –	78—80 79	– –	73—78 76	– –
Wheat middlings, flour,	2	4	78—86 82	81—84 83	– –	82—91 88	33—40 36	84—91 88	82—88 86
Wheat middlings, standard,	2	6	–	73	25	77	30	78	88
Wheat mixed feed, bran and middlings,	2	4	71—78 73	73—81 76	34—43 37	77—79 78	47—79 62	74—79 77	81—92 87
Wheat mixed feed, adulterated with corn cobs,	1	3	59—65 62	61—67 64	28—34 31	62—63 63	17—36 28	68—74 71	91—93 92
Wheat screenings,	1	2	70—87 79	– –	– –	68—81 75	45—85 65	81—89 85	92—95 94
(*b*) *Starchy.*									
Feed barley meal,	1	2	87—91 89	– –	28—47 38	86—90 88	45—96 70	92—94 93	86—87 86
Hanna barley,	3	13	– –	– –	– –	68—90 77	15—98 56	87—96 92	55—99 78
Manchuria barley,	1	2	– –	– –	– –	84—84 84	– 54	89—93 91	78—82 80

Cerealine feed,	1	3	89—92 90	– –	– –	79—81 80	72—92 82	93—97 95	78—83 81
Chop feed, corn bran and germs,	2	6	71—92 80	– –	– –	56—77 67	54—70 62	64—92 84	61—86 82
Corn bran,	2	4	70—71 70	– –	– –	53—55 54	50—65 59	74—80 77	69—85 77
Corn cobs,	1	2	59—60 59	– –	– –	13—22 17	65—66 65	60—60 60	44—56 50
Corn meal, coarse,	2	4	74—93 84	75—94 86	– –	45—54 48	– –	79—91 86	– –
Corn meal, fine,	5	8	84—90 87	89—90 90[1]	– –	48—81 65	– –	87—98 93	75—95 85[2]
Corn meal, average all trials,	12	26	74—98 88	75—94 90	– –	40—87 67	– –	79—100 92	71—99 90
Corn and cob meal,	1	3	74—83 79	– –	– –	43—65 52	2—86 45	86—91 88	82—85 84
Corn and oat feed, Victor,	1	3	74—76 75	– –	– –	66—75 71	36—58 48	81—85 83	84—88 87
Kaffir corn kernels,	2	6	29—58 43	– –	– –	28—54 41	– –	34—62 45	– –
Kaffir corn meal,	3	7	54—81 70	– –	38—99 69	36—65 56	61[3] –	67—88 79	25—81 55
White Kaffir corn heads,	1	4	14—35 24	– –	24—83 54	7—23 12	0—46 27	14—40 31	5—65 31
Dairy feed, Quaker,	3	8	58—64 62	– 52	– –	62—72 70	54—56 55	55—71 59	72—80 74
Hominy meal,	3	8	71—91 82	– –	11—60 37	54—74 65	2—100+ 67	82—94 89	88—95 92
Horse feed, H-O,	3	5	70—77 74	– 78	– –	62—81 70	52—59 56	79—85 83	74—87 80

[1] Average three trials. [2] Average five trials. [3] One trial.

EXPERIMENTS WITH RUMINANTS — *Concluded.*

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
V. CONCENTRATED FEEDSTUFFS — *Con.*									
(*b*) *Starchy* — Con.									
Milo maize meal,	1	2	77—91 84	– –	84—100 92?	61—71 66	– 100	83—86 85	87—94 90
Molasses feeds. Alma dried molasses beet pulp,	1	2	82—87 85	– –	55—69 62	59—69 64	83—84 84	89—93 91	– –
Molasses feeds. Blomo feed,	1	2	64—69 67	– –	31—32 32	61—64 63	51—72 61	73—79 76	14—17 16
Molasses feeds. Green Diamond sugar feed,	1	2	61—70 66	– –	36—39 38	68—72 70	36—52 44	70—78 74	75—92 84
Molasses feeds. Holstein sugar feed,	1	3	70—74 71	– –	24—43 33	61—71 66	26—62 44	79—82 81	86—89 88
Molasses feeds. Macon sugar feed,	1	2	69—72 71	– –	20—21 20	57—61 59	36—51 44	81—83 82	74—91 82
Molasses feeds. Sucrene dairy feed,	1	2	67—72 69	– –	28—47 38	57—64 61	70—73 72	71—75 73	93—96 95
Molasses feeds. Molasses feeds, average last four,	4	9	69	–	32	64	50	79	87
Red Orenburg millet,	2	4	– –	– –	– –	39—64 55	24 –	84—95 88	86—91 88
Black Voronezh millet,	4	8	– –	– –	– –	54—93 70	14—65 30	76—95 88	68—91 81
Sixty day oats,	1	1	–	–	–	86	50	86	79
Swedish select oats,	4	11	– –	– –	– –	67—85 77	16—55 36	76—87 81	82—97 89
Oats, unground,	2	6	66—74 70	68—74 71	2—61 25	72—81 77	15—40 31	74—79 77	87—92 89

Oat feed, Royal, many hulls,	1	3	42—51 47	42—53 48	33—40 37	64—72 69	20—43 33	50—54 51	86—92 88
Oat feed, excessive hulls,	1	3	29—38 34	- -	8—21 13	51—69 62	25—37 32	29—36 33	89—97 92
Oat feed, average last two,	2	6	40	-	25	65	32	42	90
Parson's "Six-dollar" feed, mill sweepings,	1	2	55—56 56	- -	10—14 12	56—62 59	45—50 47	63—65 64	80—81 81
Peanut feed, largely husks,	1	2	32—32 32	- -	- -	70—71 71	10—13 12	41—58 49	90—90 90
Rice meal,	1	2	71—76 74	- -	- -	- 62	- ?	89—95 92	91—92 91
Rice bran,	1	2	56—66 62	- -	1—34 18	58—68 64	13—42 21	76—81 78	52—92 72
Rye meal,	1	2	85—90 87	- -	- -	83—85 84	- -	89—94 92	63—65 64
Rice polish,	1	2	82—83 83	- -	27—36 31	65—66 66	22—23 22	92—93 93	66—81 74
Speltz or emmer, unground (Minnesota),	1	2	93—94 94	- -	51—56 53	85—88 87	82—85 84	96—97 97	90—94 92
Speltz or emmer (South Dakota),	3	9	- -	- -	- -	68—85 78	42—60 50	81—95 87	74—99 87
Speltz or emmer, average,	4	11	-	-	-	80	60	89	88
Schumacher's stock feed (corn, oat and barley),	1	2	70—72 71	- -	- -	68—72 70	46—59 52	79—79 79	87—89 88
Durum wheat,	1	2	- -	- -	- -	76—80 78	40 -	92—92 92	61—69 65
Red wheat meal,	1	2	83—88 86	- -	26—29 28	66—68 67	40 -	91—94 92	79—81 80
White Winter wheat meal,	1	2	86—91 88	- -	10—49 30	81—83 82	77 -	92—95 93	62—66 64

EXPERIMENTS WITH SWINE.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
Barley meal,	1	1	80	80	–	81	49	87	57
Linseed meal, old process,	1	4	76—79 77	– –	8—12 10	83—90 86	10—14 12	82—87 85	78—82 80
Maize kernels,	1	1	83	83	–	69	38	89	46
Maize meal,	2	2	89—90 90	91—92 92	– –	86—90 88	29—49 39	94—94 94	78—82 80
Maize meal with cobs,	1	1	76	77	–	76	29	84	82
Hog millet seed (*Panicum milia ceum*),	1	1	73	–	19	68	33	92	59
Pea meal,	1	1	90	92	–	89	78	95	50
Potatoes,	1	4	97	–	–	84	–	98	–
Wheat, whole,	1	?	72	–	–	70	30	74	60
Wheat, cracked,	1	?	82	–	–	80	60	83	70
Wheat shorts (middlings),	1	2	74—79 77	– –	– –	71—75 73	25—48 37	85—88 87	– –
Wheat bran,	1	2	54—78 66	– –	– –	74—76 75	30—39 39	56—75 66	65—78 72

EXPERIMENTS WITH HORSES.

KIND OF FODDER.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
Corn kernels,	1	2	71—78 74	- -	20—32 26	40—76 58	- -	85—92 88	43—52 48
Corn meal, same as above,	1	2	84—93 88	- -	- -	74—77 76	- -	93—99 96	70—76 73
Corn stover minus pith, ground (Marsden's process),	1	2	40—59 50	- -	6—37 22	65—70 68	38—71 55	39—54 47	48—72 60
Oat kernels,	1	2	67—77 72	- -	31—36 33	84—87 86	13—49 31	75—83 79	80—85 82
Oats, ground, same as above,	1	2	73—78 76	- -	9—49 29	81—83 82	.6—28 14	85—87 86	79—81 80
Oats, average,	2	4	74	-	31	84	22	82	81
Timothy hay,	1	2	39—48 44	- -	29—39 34	18—24 21	37—48 43	44—50 47	44—51 47

Experiments with Poultry.

Kind of Fodder.	Number of Different Lots.	Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Ash (Per Cent.).	Crude Protein (Per Cent.).	Crude Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Crude Fat (Per Cent.).
Clover, second crop, just beginning to blossom,	1	3	-	28	-	71	10	14	36
Corn kernels,	1	3	- -	- 86	- -	44—58 50	- -	90—96 92	88—95 92
Corn kernels,	2	6	- -	86—87 87	- -	68—87 81	1—25 15	88—92 90	81—87 85
Corn, cracked,	1	2	- -	83—84 83	- -	72—73 72	- -	87—89 88	87—88 87
Corn meal,	1	3	- -	- 85	- -	41—55 48	- -	91—92 91	92—94 93
Corn meal,	1	2	- -	82—84 83	- -	72—77 75	- -	84—88 86	87—88 88
Kaffir corn kernels,	1	3	- -	- 88	- -	50—55 53	17—22 20	94—98 96	71—73 74
Kaffir corn meal,	1	3	- -	- 87	- -	42—44 43	30—42 35	95—97 96	82—84 83
Meat,	1	2	- -	87—87 87	- -	90—91 91	- -	- -	86—87 87
Beef scrap,	1	2	-	80	-	93	-	-	96
Oats, whole,	2	12	- -	59—68 63	- -	68—84 75	4—11 8[1]	62—75 69	77—89 83
Oats, rolled,	1	2	- -	79—84 82	- -	78—81 80	- -	85—87 86	86—102 94
Cow peas,	1	3	- -	- 71	- -	32—48 40	2—43 18	86—88 87	87—90 89

Cow pea meal,	1	3	– –	– 72	– –	40—49 44	8—11 10	84—91 88	75—98 89
Wheat,	1	1	–	84	–	77	–	89	59
Wheat, hard,	1	1	–	82	–	71	–	81	57
Wheat, soft,	1	5	– –	81—85 82	– –	57—79 74	– 17	87—90 89	45—69 54
Wheat bran, coarse,	1	3	– –	46—47 47	– –	69—74 72	13—14 14	46—46 46	35—38 37
India wheat,	1	3	– –	67—76 73	– –	71—80 75	5—29 21	79—86 83	79—87 84

EXPERIMENTS WITH CALVES.

Whole milk,	2	8	– –	– –	– –	90—98 95	– –	– –	93—99 97
Pasteurized whole milk,	2	9	– –	– –	– –	88—95 93	– –	– –	91—99 95
Cooked whole milk,	1	3	– –	– –	– –	80—94 87	– –	– –	92—99 95
Raw skim milk,	1	3	– –	– –	– –	94—95 95	– –	– –	– –
Skim milk, with sheep,	1	3	96—102 97	– 100	46—74 62	93—96 94	– –	– 100	– 100

[1] Eight trials.

AVERAGE DIGESTION COEFFICIENTS OBTAINED WITH POULTRY.[1]

[German and American Experiments.]

KIND OF FODDER.	Number of Experiments.	Organic Matter.	Crude Protein.	Nitrogen-free Extract.	Fat.
Bran, wheat,	3	46.70	71.70	46.00	37.00
Beef scrap,	2	80.20	92.60	–	95.00
Beef (lean meat),	2	87.65	90.20	–	86.30
Barley,	3	77.17	77.32	85.09	67.86
Buckwheat,	2	69.38	59.40	86.99	89.22
Corn, whole,	16	86.87	81.58	91.32	88.11
Corn, cracked,	2	83.30	72.20	88.10	87.60
Corn meal,	2	83.10	74.60	86.00	87.60
Clover,	3	27.70	70.60	14.30	35.50
India wheat,	3	72.70	75.00	83.40	83.80
Millet,	2	–	62.40	98.39	85.71
Oats,	13	62.69	71.31	90.10	87.89
Peas,	3	77.07	87.00	84.80	80.01
Wheat,	10	82.26	75.05	87.04	53.00
Rye,	2	79.20	66.90	86.70	22.60
Potatoes,	6	78.33	46.94	84.46	–

[1] Compiled by J. M. Bartlett, Bulletin 184, Maine Agricultural Experiment Station.

Literature.

The following publications have been consulted in compiling the foregoing tables of digestibility: —

Colorado Experiment Station, Bulletins 8, 93.

Connecticut (Storrs) Experiment Station, reports for 1894–96, 1898; Bulletin 43.

Illinois Experiment Station, Bulletins 43, 58.

Kansas Experiment Station, Bulletin 103.

Louisiana Experiment Station, Bulletin 77, second series.

Maine Experiment Station, reports for 1886–91, 1893, 1894, 1897, 1898, 1900; Bulletins 110, 184.

Maryland Experiment Station, Bulletins 20, 41, 43, 51, 77, 86.

Massachusetts Agricultural Experiment Station, reports for 1895–99, 1901–05, 1907; and Digestion Experiments, Series XII., XIII., XIV., XV., unpublished.

Massachusetts, State Experiment Station, reports for 1893, 1894.

Minnesota Experiment Station, reports for 1894–96; Bulletins 26, 36, 42, 47, 80, 99.

Mississippi Experiment Station, report for 1895.

Nevada Experiment Station, Bulletins 64, 66, 71.

New York Experiment Station, reports for 1884, 1888, 1889; Bulletin 141.

North Carolina Experiment Station, Bulletins 80*c*, 81, 87*d*, 97, 118, 148, 160, 172.

Oklahoma Experiment Station, Bulletins 37, 46.

Oregon Experiment Station, Bulletins 6, 47, 85, 102.

Pennsylvania Experiment Station, reports for 1887–94, 1897, 1898, 1900–01, 1903–04, 1906–07.

South Dakota Experiment Station, Bulletin 114.

Tennessee Experiment Station, unpublished data.

Texas Experiment Station, Bulletins 13, 15, 19, 104.

Utah Experiment Station, Bulletins 16, 54, 58.

United States Department of Agriculture, Bureau of Animal Industry, Bulletins 56, 106.

Wisconsin Experiment Station, report for 1889; Bulletin 3.

Wyoming Experiment Station, Bulletins 69, 78.

TABLE V. — COMPILATION OF ANALYSES OF AGRICULTURAL CHEMICALS, REFUSE SALTS, PHOSPHATES, GUANOS, ASHES, LIME COMPOUNDS, MARLS, BY-PRODUCTS, REFUSE SUBSTANCES AND ANIMAL EXCREMENTS.

H. D. HASKINS AND L. S. WALKER.

A. CHEMICALS AND REFUSE SALTS.
- (*a*) Nitrogen chemicals.
- (*b*) Potash chemicals.
- (*c*) Refuse salts.

B. PHOSPHATES AND GUANOS.
- (*a*) Natural phosphates.
- (*b*) Dissolved phosphates.
- (*c*) Guanos.

C. ASHES, LIME COMPOUNDS AND MARLS.
- (*a*) Ashes.
- (*b*) Lime compounds.
- (*c*) Marls.

D. BY-PRODUCTS AND REFUSE SUBSTANCES.
- (*a*) Abattoir products.
- (*b*) Fish products.
- (*c*) Seaweeds.
- (*d*) Vegetable products.
- (*e*) Wool products.
- (*f*) Miscellaneous substances unclassified.

E. ANIMAL EXCREMENTS.

F. INSECTICIDES.

As a rule, the analyses reported in the following compilation were made at this laboratory.[1] Some of them were made many years ago. Refuse products from various manufacturing industries are likely to vary more or less in composition, due to frequent changes in the parent industry. The revision of the

[1] In the compilation of analyses of seaweeds, five of said analyses were taken from Bulletin No. 21 of the Rhode Island Agricultural Experiment Station.

compilation every five years, however, insures quite reliable figures in most instances. In case of the agricultural chemicals and by-products which are commonly known to the fertilizer trade, the present compilation includes the samples collected by our inspectors during the last five years, as well as those samples sent by farmers and farmer organizations. In all cases where samples are forwarded for analysis, they are taken according to printed directions furnished from this office, which is a reasonable assurance that the analyses are representative of the materials sampled. In many instances extremely wide variations occur in different analyses of the same product. This emphasizes the importance of careful sampling as well as the purchase of such materials on a specific guarantee of plant food which they furnish.

In the majority of instances only the highest, lowest and average percentage of nitrogen, potash and phosphoric acid are given in the tables, but it should be remembered that blanks do not imply the absence of the other ingredients.

A. Chemicals and Refuse Salts.

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
(a) Nitrogen Chemicals.																							
Calcium cyanide,	3	.71	–	–	–	19.06	–	–	–	–	–	–	–	–	–	–	63.19	–	2.10	–	–	–	1.00
Carbonate of ammonia,	1	–	–	–	–	22.23	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitrate of potash,	10	1.58	–	14.58	11.42	12.57	45.62	43.48	44.20	–	–	–	–	–	–	–	–	–	–	–	–	9.74	–
Nitrate of soda,	186	1.76	–	16.57	14.14	15.38	–	–	–	–	–	–	–	–	–	35.50	–	–	–	–	–	.50	.50
Nitrate of lime,	1	5.88	–	–	–	12.00	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitrogenous chalk,	4	.78	–	9.88	8.42	9.11	–	–	–	–	–	–	–	–	–	–	29.30	–	–	–	–	–	2.28
Phosphate of ammonia,	1	6.05	–	–	–	10.87	–	–	–	–	–	43.86	–	43.86	–	–	–	–	–	12.46	–	–	.82
Sulfate of ammonia,	35	1.01	–	22.72	19.44	20.91	–	–	–	–	–	–	–	–	–	–	–	–	–	60.00	–	–	–
(b) Potash Chemicals.																							
Carbonate of potash, high grade,	26	2.25	–	–	–	–	67.20	55.68	63.02	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Carbonate of potash and magnesia,	2	18.22	–	–	–	–	20.00	18.48	19.24	–	–	–	–	–	–	–	–	19.52	–	–	–	–	.39
Carnallite,	1	–	–	–	–	–	–	–	13.68	–	–	–	–	–	–	7.66	–	13.19	–	.56	–	41.56	–
Hard salts,	1	.45	–	–	–	–	–	–	17.30	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Kainit,	24	3.04	–	–	–	–	16.50	10.90	13.07	–	–	–	–	–	–	18.97	2.37	6.37	–	20.25	–	20.64	2.13
Krugite,	1	4.82	–	–	–	–	–	–	8.42	–	–	–	–	–	–	5.27	12.45	8.79	–	31.94	–	6.63	14.96

Muriate of potash,	134	1.50	–	–	–	–	58.08	43.08	49.82	–	–	–	–	–	–	6.69	–	.55	–	–	–	48.80	.70
Phosphate of potash,	1	3.76	–	–	–	–	–	–	32.55	–	–	37.50	–	37.50	–	–	–	–	–	13.43	–	–	.92
Sulfate of potash, high grade,	113	.90	–	–	–	–	53.60	45.40	49.69	–	–	–	–	–	–	4.46	–	1.50	–	45.72	–	–	.75
Sulfate of potash and magnesia,	52	4.65	–	–	–	–	31.68	19.55	26.37	–	–	–	–	–	–	6.25	2.57	13.65	–	44.62	–	1.92	2.26
Silicate of potash,	5	8.26	–	–	–	–	27.62	18.62	20.20	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vegetable potash,	11	3.40	–	–	–	–	27.84	23.96	25.59	–	–	2.55	–	–	–	–	20.65	–	–	–	–	–	9.70
(c) *Refuse Salts.*																							
Cyanide of potash refuse,	1	39.23	–	–	–	.96	–	–	7.36	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Niter salt cake,	2	6.03	–	–	–	2.29	–	–	.87	–	–	–	–	–	–	29.56	–	–	–	47.77	–	–	3.92
Sulfate of magnesia,	12	24.51	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.82	17.18	–	36.10	–	–	5.73
Sulfate of soda,	1	1.38	–	–	–	–	–	–	–	–	–	–	–	–	–	45.50	–	–	–	59.43	–	–	–
Saltpeter waste,	27	3.63	–	10.12	.52	3.41	50.94	1.55	24.82	–	–	–	–	–	–	37.04	.79	.19	–	1.85	–	44.37	–

B. Phosphates and Guanos.

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
(a) Natural Phosphate.																							
Apatite,	2	.07	–	–	–	–	–	–	–	37.74	32.62	35.18	–	2.09	33.09	–	–	–	–	–	–	–	–
Arkansas rock phosphate,	1	.91	–	–	–	–	–	–	–	–	–	25.10	–	–	–	–	–	–	–	–	–	–	–
Belgian phosphate,	1	.21	–	–	–	–	–	–	–	–	–	9.54	–	–	–	–	41.27	–	–	–	–	–	–
Bone ash,	13	3.09	–	–	–	–	–	–	–	39.14	28.38	35.96	–	4.07	31.89	–	52.12	–	–	–	–	–	.96
Bone black,	5	4.60	–	–	–	–	–	–	–	30.54	16.56	28.28	–	–	–	–	–	–	–	–	–	–	3.64
Brockville phosphate,	1	2.50	–	–	–	–	–	–	–	–	–	35.21	–	–	–	–	–	–	–	–	–	–	6.46
Florida rock phosphate,	2	.53	–	–	–	–	–	–	–	40.34	33.10	36.72	–	.10	36.62	–	–	–	–	–	–	–	–
Florida soft phosphate,	2	5.22	–	–	–	–	–	–	–	–	–	23.24	–	.85	22.40	–	–	–	–	–	–	–	–
Novassa phosphate,	1	5.77	–	–	–	–	–	–	–	–	–	24.56	–	1.66	22.90	–	–	–	–	–	–	–	–
South American bone ash,	1	7.00	–	–	–	–	–	–	–	–	–	35.89	–	–	–	–	44.89	–	–	–	–	–	4.50
South Carolina rock phosphate,	12	1.36	–	–	–	–	–	–	–	31.87	20.60	26.62	–	3.40	24.60	–	–	–	–	–	–	–	–
Tennessee phosphate,	1	1.09	–	–	–	–	–	–	.44	–	–	27.97	–	–	–	–	–	–	–	–	–	–	–
(b) Dissolved Phosphates.																							
Acid phosphate,	97	10.49	–	–	–	–	–	–	–	19.44	11.60	16.07	9.53	4.62	1.92	–	–	–	–	–	–	–	–
Basic slag phosphate,	42	.68	–	–	–	–	.52	.04	.38	–	–	18.08	–	14.17	2.79	–	44.33	–	16.18	–	2.51	–	9.14

Dissolved bone,	27	8.09	-	-	-	2.57	-	-	-	24.12	14.58	16.84	3.49	9.37	3.98	-	-	-	-	-	-	-	-
Dissolved bone black,	67	11.09	-	-	-	-	-	-	-	21.14	14.69	17.40	12.24	4.04	1.12	-	-	-	-	-	-	-	-
Double super phosphate,	2	6.27	-	-	-	-	-	-	-	50.14	45.42	47.78	18.36	20.97	8.45	-	-	-	-	-	-	-	-
Precipitated phosphate,	1	9.40	-	-	-	-	-	-	-	-	-	25.45	.72	24.17	.56	-	32.22	-	-	-	-	-	-
Upton phosphate,	1	9.07	-	-	-	-	-	-	-	-	-	40.15	-	37.84	2.31	-	-	-	-	-	-	-	-
(c) Guanos.																							
Guano, bat (Texas),	9	40.09	18.24	10.51	2.58	6.47	-	-	1.31	6.53	1.00	3.76	-	-	-	-	-	-	-	-	-	-	2.00
Guano, bat (Florida),	2	15.66	-	-	-	9.74	-	-	1.77	3.44	3.26	3.35	-	-	-	-	-	-	-	-	-	-	19.33
Guano, bat (Havana, Cuba),	2	5.83	-	6.96	1.70	4.33	1.20	.53	.86	14.00	5.04	9.52	-	-	-	6.17	11.04	-	5.76	-	-	-	9.47
Guano (Cuban),	5	24.27	-	2.74	.63	1.67	-	-	-	16.16	11.54	13.35	-	-	-	-	-	-	-	-	-	-	3.17
Guano, Caribbean (Orchilla),	12	7.31	-	-	-	-	-	-	-	35.43	18.14	26.77	-	-	-	-	39.95	3.29	-	2.68	-	-	1.27
Guano (Damaraland),	1	17.70	-	-	-	5.79	-	-	3.53	-	-	14.78	4.90	5.79	4.09	7.03	14.21	2.05	-	5.94	-	5.76	9.26
Guano, Mona Island,	1	13.32	-	-	-	.76	-	-	-	-	-	21.88	-	7.55	14.33	-	37.49	-	-	-	-	-	2.45
Guano, Peruvian,	30	13.58	37.61	13.50	4.44	6.36	4.08	1.14	2.62	20.60	5.96	14.85	3.72	5.49	5.64	-	12.85	-	-	-	-	-	6.60
Guano, rat (Florida),	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	-	-	-	1.15

C. Ashes, Lime Compounds and Marls.

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
(a) Ashes.																							
Ashes, bamboo,	1	31.84	–	–	–	–	–	–	1.92	–	–	1.80	–	–	–	–	1.56	–	–	–	–	–	–
Ashes, bituminous coal,	2	3.66	–	–	–	–	–	–	.38	–	–	.44	–	–	–	–	1.88	–	–	–	–	–	74.17
Ashes, brick-yard,	2	.58	–	–	–	–	3.59	3.32	3.45	1.61	1.33	1.47	–	–	–	–	24.33	–	–	–	–	–	47.63
Ashes, blue works,	1	12.14	63.78	–	–	–	–	–	9.02	–	–	–	–	–	–	–	–	–	–	–	–	–	12.30
Ashes, corn-cob,	2	5.47	–	–	–	1.18	42.38	7.08	24.73	7.08	2.37	4.72	–	–	–	–	7.00	–	–	–	–	–	38.12
Ashes, cottonseed hull,	39	7.66	–	–	–	–	32.80	13.44	21.86	15.53	6.26	8.60	–	6.88	1.28	–	7.22	12.47	–	7.31	–	–	10.01
Ashes, cremation swill,	15	4.86	–	–	–	–	8.83	1.25	3.97	32.36	7.47	14.16	–	–	–	–	33.58	1.87	4.65	–	–	–	21.57
Ashes, garbage,	3	3.01	–	–	–	–	6.01	3.72	5.13	10.21	7.16	8.77	–	–	–	15.65	20.22	1.16	9.22	4.57	10.85	4.75	28.42
Ashes, hard pine,	1	.75	–	–	–	–	–	–	10.16	–	–	2.24	–	–	–	–	24.95	–	–	–	–	–	29.90
Ashes, hay and straw,	1	.40	–	–	–	–	–	–	1.55	–	–	1.02	–	–	–	–	5.22	–	–	–	–	–	66.35
Ashes, hemp,	1	none	–	–	–	–	–	–	2.48	–	–	1.74	–	–	–	–	60.47	–	–	–	–	–	3.14
Ashes, jute waste,	1	.19	–	–	–	–	–	–	.51	–	–	.54	–	–	–	3.84	6.04	.39	7.60	–	–	.57	81.02
Ashes, leather scrap,	3	5.94	–	–	–	.15	3.36	1.00	2.23	3.96	1.80	2.89	–	–	–	–	7.80	–	–	–	–	–	46.08
Ashes, lime,	42	9.10	–	–	–	–	4.93	.16	1.77	1.68	.03	.70	–	–	–	–	44.58	1.30	–	–	–	–	7.27
Ashes, log wood,	1	1.50	–	–	–	–	–	–	.08	–	–	2.30	–	–	–	–	3.90	–	–	–	–	–	9.70

Ashes, magnolia,	1	1.58	–	–	–	–	–	–	2.56	–	–	.45	–	–	–	–	–	–	–	–	–	–	6.12
Ashes, peach-tree trimmings,	1	.54	–	–	–	–	–	–	4.92	–	–	2.44	–	–	–	7.53	18.74	–	10.50	2.20	–	–	13.54
Ashes, peat,	3	6.50	–	–	–	–	.46	.07	.33	1.62	.11	.72	–	–	–	–	7.23	1.63	6.13	–	–	–	45.17
Ashes, picker waste,	1	.28	–	–	–	–	–	–	6.56	–	–	1.18	–	–	–	–	–	–	–	–	–	–	63.43
Ashes, pine wood,	1	2.76	–	–	–	–	–	–	4.37	–	–	3.07	–	–	–	–	23.61	–	–	–	–	–	37.46
Ashes, pulp,	1	none	–	–	–	–	–	–	.46	–	–	.12	–	–	–	–	67.72	–	–	–	–	–	7.00
Ashes, railroad ties,	1	4.70	–	–	–	–	–	–	.92	–	–	.56	–	–	–	–	2.51	–	–	–	–	–	80.20
Ashes, refuse from sawdust,	1	13.92	–	–	–	–	–	–	3.58	–	–	7.92	–	–	–	–	34.76	–	–	–	–	–	25.27
Ashes, roofing paper,	1	.06	–	–	–	–	–	–	.08	–	–	.65	–	–	–	–	5.65	12.90	11.17	–	–	–	63.02
Ashes, seaweed,	1	1.47	–	–	–	–	–	–	.92	–	–	.30	–	–	–	8.76	6.06	4.37	–	2.98	–	6.60	68.65
Ashes, soft coal and sawdust,	1	3.36	–	–	–	–	–	–	.73	–	–	.74	–	–	–	–	2.80	–	–	–	–	–	69.53
Ashes, soft and buckwheat coal,	1	.85	–	–	–	–	–	–	.45	–	–	.37	–	–	–	–	1.70	–	–	–	–	–	–
Ashes, spent tan bark,	5	4.84	–	–	–	–	2.87	.60	1.81	2.77	.13	1.36	–	–	–	–	31.11	3.39	1.78	–	–	–	25.21
Ashes, tan bark,	1	1.50	–	–	–	–	–	–	.52	–	–	.77	–	–	–	–	24.29	–	–	–	–	–	13.54
Ashes, walnut wood,	1	3.79	–	–	–	–	–	–	5.06	–	–	2.07	–	–	–	–	40.73	–	–	–	–	–	2.29
Ashes, wood and coal,	1	1.32	–	–	–	–	–	–	.44	–	–	1.15	–	–	–	–	2.39	–	–	–	–	–	40.94
Ashes, wood,	735	12.67	–	–	–	–	13.58	1.12	5.13	6.07	.06	1.51	–	–	–	–	32.44	3.31	7.43	–	–	–	16.52
Ashes, wool waste,	1	8.40	–	–	–	–	–	–	27.24	–	–	.26	–	–	–	–	2.88	–	–	–	–	–	27.82
Acetylene gas tank refuse,	2	30.07	–	–	–	–	–	–	–	–	–	–	–	–	–	–	42.65	–	–	–	8.17	–	2.48
Wood charcoal,	2	2.65	–	–	–	–	–	–	.40	–	–	.16	–	–	–	–	–	–	–	–	–	–	1.58
(b) Lime Compounds.																							
Agricultural lime,	38	2.79	–	–	–	–	–	–	–	–	–	–	–	–	–	–	61.26	3.08	2.93	–	13.55	–	4.68
Bleachery refuse,	2	4.19	–	–	–	–	1.24	.35	.79	–	–	–	–	–	–	11.69	35.79	–	–	–	–	–	23.09

C. Ashes, Lime Compounds and Marls — *Concluded.*

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
(b) *Lime Compounds* — Con.																							
Boiler cleanings,	1	3.44	–	–	–	.28	–	–	4.15	–	–	1.14	–	–	–	–	21.92	–	–	–	–	–	24.32
Burned lump lime,	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	93.63	–	–	–	–	–	1.33
Carbonate of lime,	4	.56	–	–	–	–	–	–	–	–	–	–	–	–	–	–	52.33	–	–	–	40.75	–	.42
Carbonate of lime (coral),	2	19.76	–	–	–	.28	.14	.11	.13	.21	.16	.18	–	–	–	.32	38.18	.93	.62	–	43.39	–	9.49
Gas-house lime,	5	11.16	–	–	–	–	–	–	–	–	–	–	–	–	–	–	48.19	8.30	–	19.66	–	–	8.99
Ground lime stone (unburned),	1	.28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	42.56	–	–	–	30.56	–	19.66
Gypsum,	3	8.01	–	–	–	–	–	–	–	–	–	–	–	–	–	–	36.00	–	–	51.43	–	–	–
Lime waste from tannery,	2	.88	–	–	–	.65	–	–	–	–	–	–	–	–	–	–	54.78	–	–	–	–	–	2.83
Lime waste from sugar factory,	1	36.30	–	–	–	–	–	–	.22	–	–	2.25	–	–	–	–	27.51	–	–	–	–	–	.26
Lime waste from soda factory,	1	24.07	–	–	–	–	–	–	–	–	–	–	–	–	–	–	14.86	1.36	–	23.14	–	–	1.33
Lime sludge from glue factory,	1	37.20	–	–	–	.63	–	–	–	–	–	.15	–	–	–	–	19.62	–	–	–	14.51	–	–
Magnesia lime,	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	47.55	32.75	–	–	1.35	–	–
Nova Scotia plaster (gypsum),	17	6.45	–	–	–	–	–	–	–	–	–	–	–	–	–	–	33.74	.75	–	44.87	–	–	5.79
Onondaga plaster, New York, gypsum,	4	13.27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30.00	4.66	–	32.50	8.20	–	9.83
Oyster shell lime, partially burned,	7	5.13	–	–	–	.17	–	–	–	–	–	.36	–	–	–	–	45.87	–	–	–	20.73	–	10.08

Plastering,	1	7.20	–	–	–	–	–	–	–	–	–	.22	–	–	–	–	11.50	–	–	–	–	–	66.50
Soot,	5	7.92	–	.68	.18	.60	1.57	.17	.58	1.02	.23	.76	–	–	–	–	3.49	1.19	6.38	–	–	–	77.33
Soot, from soft coal,	1	32.61	–	–	–	.97	–	–	.04	–	–	trace	–	–	–	–	4.80	–	–	–	–	–	16.55
(c) Marls.																							
Ammoniated marl,	1	3.31	–	–	–	1.61	–	–	–	–	–	10.39	–	.41	9.98	–	–	–	–	–	–	–	–
Marl, Caledonia (New York),	1	.51	–	–	–	–	–	–	–	–	–	–	–	–	–	–	54.52	–	–	–	42.08	–	–
Marl, green sand (Virginia),	1	1.25	–	–	–	–	–	–	1.14	–	–	9.37	–	–	–	–	25.78	–	5.13	–	–	–	41.32
Marl, Massachusetts,	7	13.70	–	–	–	–	–	–	.24	2.72	.06	1.05	–	–	–	–	40.50	.64	.69	–	28.57	–	3.44
Marl, North Carolina,	1	.70	–	–	–	–	–	–	.04	–	–	.56	–	–	–	–	21.95	.61	–	–	–	–	50.18
Marl, Virginia,	2	15.98	–	–	–	–	.61	.37	.49	.09	.08	.09	–	–	–	–	7.25	.21	–	.66	7.25	–	64.23
Olive earth (Virginia),	1	1.97	–	–	–	–	–	–	.24	–	–	13.73	–	–	–	–	19.16	–	6.00	–	–	–	50.55

D. By-Products and Refuse Substances.

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
(a) Abbattoir Products.																							
Ammoniate,	1	5.88	–	–	–	11.33	–	–	–	–	–	3.43	–	–	–	–	–	–	–	–	–	–	1.38
Blood and bone,	5	5.97	–	7.19	5.70	6.23	–	–	–	12.86	11.38	12.14	–	4.41	7.73	–	–	–	–	–	–	–	–
Bone dust,	1	5.06	–	–	–	3.06	–	–	–	–	–	17.80	–	7.24	10.56	–	–	–	–	–	–	–	–
Bone fiber,	1	5.38	–	–	–	4.61	–	–	–	–	–	12.44	–	6.76	5.68	–	–	–	–	–	–	–	–
Beef scrap,	1	7.12	–	–	–	7.46	–	–	–	–	–	9.42	–	3.10	6.32	–	–	–	–	–	–	–	–
Bone soup,	2	87.01	–	1.42	1.14	1.28	–	–	.01	1.26	.04	.65	–	–	–	–	–	–	–	–	–	–	–
Bone scrapings,	1	–	–	–	–	4.04	–	–	–	–	–	27.22	–	–	–	–	–	–	–	–	–	–	–
Concentrated tankage,	1	7.99	–	–	–	11.16	–	–	–	–	–	1.72	–	–	–	–	–	–	–	–	–	–	–
Condensed bone steam,	1	81.75	–	–	–	1.94	–	–	–	–	–	.07	–	–	–	–	–	–	–	–	–	–	–
Dried blood,	61	10.48	6.37	13.78	7.99	10.26	–	–	–	8.83	.03	2.69	–	–	–	–	–	–	–	–	–	–	–
Dried soup from meat and bone,	1	14.80	8.40	–	–	9.97	–	–	–	–	–	.53	–	–	–	–	–	–	–	–	–	–	.64
Dried soup from rendering cattle feet,	1	10.80	7.50	–	–	14.47	–	–	–	–	–	.46	–	–	–	–	–	–	–	–	–	–	.26
Fresh-cut bone,	1	24.98	–	–	–	3.00	–	–	–	–	–	16.85	–	5.26	11.59	–	–	–	–	–	–	–	–
Ground bone (raw),	17	6.12	–	6.32	2.19	3.82	–	–	–	27.40	13.94	22.75	–	7.43	15.32	–	–	–	–	–	–	–	–
Ground bone (steamed),	160	6.92	–	3.63	.97	2.99	–	–	–	31.37	23.22	24.93	–	9.25	15.68	–	–	–	–	–	–	–	–

Ground bone damaged by salt water,	1	32.81	–	–	–	1.78	–	–	–	–	–	17.21	–	5.26	11.95	–	–	–	–	–	–	–	–
Horn shavings,	1	4.83	–	–	–	15.31	–	–	–	–	–	.42	–	–	–	–	–	–	–	–	–	–	–
Horn waste,	5	8.59	–	13.96	5.18	10.59	–	–	–	16.78	.04	4.22	–	–	–	–	–	–	–	–	–	–	–
Horn and hoof waste,	3	10.17	7.63	15.49	11.84	13.25	–	–	–	2.30	1.36	1.83	–	–	–	–	–	–	–	–	–	–	–
Hoof meal,	5	8.63	–	15.19	13.08	13.85	–	–	–	.77	trace	.47	–	–	–	–	2.06	–	–	–	–	–	–
Hair waste,	1	6.52	22.77	–	–	9.22	–	–	.14	–	–	.51	–	–	–	4.10	–	–	–	–	–	–	–
Meat meal,	2	5.51	8.55	9.97	9.23	9.60	–	–	–	3.65	3.08	3.37	–	–	–	–	–	–	–	–	–	–	–
Meat mass,	5	12.09	13.60	11.50	9.69	10.44	–	–	–	3.58	.56	2.07	–	–	–	–	–	–	–	–	–	–	.58
Meat scrap,	2	24.79	–	–	–	6.33	–	–	–	–	–	5.79	–	–	–	–	–	–	–	–	–	–	–
Meat and bone,	12	8.64	–	–	–	5.29	–	–	–	–	–	16.81	–	7.06	9.74	–	–	–	–	–	–	–	–
Rawhide waste,	3	32.95	8.03	13.91	3.29	10.07	–	–	–	1.06	.24	.65	–	–	–	–	4.44	–	–	–	–	–	–
Soup from horse rendering,	1	92.14	–	–	–	1.12	–	–	–	–	–	.14	–	–	–	–	–	–	–	–	–	–	–
Tankage,	147	7.96	–	11.27	3.14	5.95	–	–	–	21.62	.76	13.89	–	6.49	7.40	–	16.84	–	–	–	–	–	–
Undried tankage,	1	29.00	–	–	–	1.06	–	–	–	–	–	3.51	–	2.94	.51	–	–	–	–	–	–	–	–
(b) Fish Products.																							
Bone from fish,	1	8.78	–	–	–	4.82	–	–	–	–	–	23.54	–	8.04	15.50	–	–	–	–	–	–	–	–
Dry ground fish,	145	9.89	–	10.91	6.06	8.35	–	–	–	18.32	5.50	8.58	–	5.15	3.43	–	–	–	–	–	–	–	–
Fish with 20 per cent. to 40 per cent. water,	10	30.19	20.59	7.41	4.22	5.97	–	–	–	8.32	4.68	7.09	.74	2.69	3.66	–	–	–	–	–	–	–	1.68
Fish with more than 40 per cent. water,	10	45.46	15.50	7.60	2.43	4.97	–	–	–	8.56	2.94	5.08	1.17	1.33	2.58	–	–	–	–	–	–	–	1.35
(c) Sea Weeds.																							
Broad leaf kelp (*Laminaria Digitala*),	3	87.50	–	.29	.16	.23	.50	.12	.31	.08	.04	.06	–	–	–	–	.41	.22	–	–	–	–	.05
Eel grass,	2	35.39	15.60	.96	.70	.83	1.61	.21	.91	.41	.22	.32	–	–	–	1.63	2.13	.11	–	–	–	–	1.06
Eel grass wrack (*Lostera Marina*),	3	81.19	–	.52	.20	.35	.43	.13	.32	.09	.03	.07	–	–	–	–	.51	.32	–	–	–	–	.12

D. By-Products and Refuse Substances — *Continued.*

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analysis.	Moisture.	Ash.	Nitrogen. Maximum.	Nitrogen. Minimum.	Nitrogen. Average.	Potash. Maximum.	Potash. Minimum.	Potash. Average.	Total Phosphoric Acid. Maximum.	Total Phosphoric Acid. Minimum.	Total Phosphoric Acid. Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
(*c*) *Sea Weeds* — Con.																							
Irish or Carogeen moss (*Chondrus Crispus*),	3	76.13	–	.81	.34	.57	1.46	.66	1.02	.20	.10	.13	–	–	–	–	.49	.33	–	–	–	–	.09
Kelp or ribbon weed (*Laminaria Saccharina*).	3	87.99	–	.22	.12	.17	.17	.14	.16	.06	.03	.05	–	–	–	–	.38	.17	–	–	–	–	.04
Rockweed (green), ...	1	68.50	23.70	–	–	.62	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rockweed (dry), ...	2	13.73	35.75	1.45	1.07	1.26	4.89	1.56	3.22	2.75	.14	1.44	–	–	–	5.97	4.88	.96	1.22	–	–	.16	–
Round stalked rockweed (*Ascophyleum nodaseum*).	3	77.26	–	.32	.18	.24	.75	.55	.64	.08	.08	.08	–	–	–	–	.48	.35	–	–	–	–	.03
Sea weed (decomposed), ...	1	78.93	–	–	–	.55	–	–	.15	–	–	.04	–	–	–	–	.24	–	–	–	–	–	13.97
(*d*) *Vegetable Products.*																							
Banana skins, ...	1	13.99	–	–	–	.24	–	–	5.46	–	–	1.80	–	–	–	–	–	–	–	–	–	–	–
Blue-green algæ (*Lungbia Majasculas*), .	1	16.26	–	–	–	4.25	–	–	.79	–	–	.19	–	–	–	3.53	2.06	1.18	–	–	–	–	5.53
Brewers' grains (rotten), ...	1	78.77	–	–	–	.72	–	–	.04	–	–	.43	–	–	–	–	.26	.15	–	–	–	–	.59
Brewery, kiln dust from, ...	1	9.72	–	–	–	4.32	–	–	2.16	–	–	.96	–	–	–	–	.78	–	–	–	–	–	7.11
Broom corn seed, ...	1	7.40	–	–	–	1.51	–	–	.50	–	–	.57	–	–	–	–	–	–	–	–	–	–	–
Calico works, refuse from, ...	1	4.07	–	–	–	4.28	–	–	–	–	–	11.95	–	–	–	–	–	–	–	–	–	–	–
Castor bean pomace, ...	24	8.20	5.70	6.17	4.65	5.22	3.40	.64	1.21	2.26	1.57	2.07	–	–	–	–	.92	.29	.82	–	–	–	1.75
Cassava waste, ...	1	9.03	–	–	–	.33	–	–	.28	–	–	.06	–	–	–	–	.61	–	–	–	–	–	–

Cork dust,	1	.74	–	–	–	.59	–	–	.33	–	–	.10	–	–	–	–	.74	.08	–	–	–	–	.24
Cocoa nut fibre pit,	1	6.20	3.78	–	–	.34	–	–	.84	–	–	.03	–	–	–	–	.57	–	–	–	–	–	1.01
Cocoa shells,	2	4.56	15.42	2.57	2.33	2.45	3.39	2.48	2.92	1.02	.36	.69	–	–	–	–	.95	–	2.79	–	–	–	2.85
Cocoa, damaged,	1	6.60	7.14	–	–	3.10	–	–	2.49	–	–	1.66	–	–	–	–	trace	–	–	–	–	–	–
Cottonseed compost,	3	45.35	–	.93	.52	.75	.76	.32	.55	.62	.39	.48	–	–	–	–	1.82	–	–	–	–	–	13.94
Cottonseed droppings,	1	4.08	–	–	–	.96	–	–	1.85	–	–	.20	–	–	–	–	.66	–	–	–	–	–	–
Cottonseed dust,	1	4.38	–	–	–	1.22	–	–	1.48	–	–	.54	–	–	–	–	1.48	–	–	–	–	–	–
Cotton waste (wet),	4	24.02	34.42	1.34	.84	1.21	.76	.43	.64	.74	.56	.65	–	–	–	–	2.73	–	–	–	–	–	38.16
Cotton waste (dry),	19	6.92	13.05	1.60	.55	1.19	1.62	.48	1.47	.66	.08	.37	–	–	–	–	2.79	–	–	–	–	–	13.27
Cottonseed meal,	346	7.25	14.70	7.99	3.24	6.59	2.10	1.41	1.65	3.39	1.71	2.57	–	–	–	–	.26	–	.38	–	–	–	.30
Damaged grain,	3	42.15	–	1.97	.84	1.44	.43	.16	.28	.83	.35	.55	–	–	–	–	–	–	–	–	–	–	–
Fiber waste,	1	61.53	–	–	–	.22	–	–	.49	–	–	.10	–	–	–	–	.36	–	–	–	–	–	.53
German peat moss,	1	9.50	1.14	–	–	.72	–	–	.06	–	–	.05	–	–	–	–	.21	–	–	–	–	–	.36
Glucose factory refuse,	1	.13	–	–	–	–	–	–	–	–	–	42.76	–	2.88	39.88	–	38.78	–	2.92	3.00	–	–	–
Glucose refuse,	1	8.10	–	–	–	2.62	–	–	.15	–	–	.29	–	–	–	–	.18	.02	–	–	–	–	.07
Gluten from starch manuf. (wet),	1	66.10	.08	–	–	5.00	–	–	none	–	–	.03	–	–	–	–	–	–	–	–	–	–	–
Gluten from starch manuf. (dry ground),	1	5.40	1.52	–	–	12.29	–	–	.10	–	–	.41	–	–	–	–	–	–	–	–	–	–	–
Hop refuse,	3	85.35	1.71	.69	.49	.59	.06	.05	.05	.17	.10	.12	–	–	–	–	.27	–	–	–	–	–	.78
Jadoo fiber,	2	10.20	11.60	.97	.77	.87	.48	.38	.43	1.24	.26	.75	–	–	–	–	3.50	–	–	–	–	–	4.05
Jute waste,	1	13.10	–	–	–	1.50	–	–	.08	–	–	.72	–	–	–	–	–	–	–	–	–	–	–
Linseed meal,	24	8.93	7.68	6.42	5.23	5.76	1.62	1.32	1.51	2.15	1.36	1.58	–	–	–	–	.47	–	.51	–	–	–	.95
Linen waste,	1	–	–	–	–	.99	–	–	.23	–	–	.53	–	–	–	–	–	–	–	–	–	–	38.94
Madder,	2	11.93	–	–	–	.91	–	–	2.40	–	–	.35	–	–	–	–	3.93	.51	–	–	–	–	4.67

D. By-Products and Refuse Substances — *Continued.*

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
(*d*) *Vegetable Products* — Con.																							
Morocco factory waste,	1	22.72	–	–	–	1.16	–	–	.36	–	–	2.56	–	–	–	–	19.60	–	–	1.24	–	–	24.17
Muck (dry),	12	6.24	64.23	2.10	.26	.95	–	–	–	–	–	.31	–	–	–	–	.77	–	–	–	–	–	–
Muck (wet),	50	65.60	11.32	1.35	.12	.50	.16	.02	.05	.19	.01	.06	–	–	–	–	.40	–	–	–	–	–	6.73
Mud,	6	46.19	53.37	.65	.19	.34	.15	.11	.14	.06	.02	.04	–	–	–	–	.15	–	–	–	–	–	27.93
Mussel mud (dry),	1	2.24	72.02	–	–	.72	–	–	–	–	–	.35	–	–	–	–	23.39	–	8.26	–	–	–	37.60
Peat, dry ground,	6	6.83	32.67	2.74	1.02	2.09	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Peat, partially dried,	5	45.30	20.47	1.88	.34	.92	–	–	.04	.11	trace	.08	–	–	–	–	.88	–	–	–	–	–	16.23
Pine needles,	1	9.48	3.42	–	–	.46	–	–	.03	–	–	.12	–	–	–	–	–	–	–	–	–	–	1.22
Pine barren grass,	1	8.48	2.40	–	–	.16	–	–	.07	–	–	.18	–	–	–	–	–	–	–	–	–	–	1.67
Salt marsh mud,	6	60.72	30.99	.31	.18	.25	–	–	.14	–	–	.08	–	–	–	–	.11	–	–	–	–	2.06	37.88
Sediment from water filter,	1	94.22	–	–	–	.12	–	–	–	–	–	.05	–	–	–	–	–	–	–	–	–	–	–
Sediment from bottom of pond,	4	41.91	87.57	.40	.13	.26	–	–	.44	–	–	.06	–	–	–	–	.64	–	–	–	–	–	72.96
Spent brewers' grain,	1	73.10	–	–	–	1.23	–	–	.07	–	–	.33	–	–	–	–	–	–	–	–	–	–	–
Silt deposit,	1	7.15	–	–	–	1.14	–	–	.39	–	–	.25	–	–	–	–	.70	–	–	–	–	–	–
Starch waste from rubber factory,	1	10.01	.23	–	–	.02	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Sugar beet refuse,	1	7.70	–	–	–	6.39	–	–	9.72	–	–	trace	–	–	–	7.00	trace	–	–	2.82	trace	1.87	–
Sugar house refuse,	1	42.70	63.19	–	–	1.08	–	–	.10	–	–	7.42	–	6.91	.51	–	–	–	–	–	–	–	–
Sugar waste,	1	64.13	–	–	–	2.18	–	–	.19	–	–	.72	–	–	–	–	3.50	–	–	–	–	–	–
Sumac waste from tannery,	2	48.27	–	1.19	1.18	1.18	3.25	.21	1.73	.09	.09	.09	–	–	–	–	2.57	–	–	–	–	–	2.01
Tartar pomace,	2	8.85	–	–	–	4.22	–	–	2.25	–	–	3.93	–	–	–	–	6.83	–	4.00	–	–	–	12.76
Teopik fibre,	1	56.54	–	–	–	.53	–	–	1.26	–	–	.55	–	–	–	–	5.15	–	–	–	–	–	.75
Tobacco dust,	5	5.04	58.68	2.25	1.54	1.80	6.81	1.53	2.93	1.28	.36	.61	–	–	–	–	3.09	–	–	–	–	–	31.18
Tobacco leaves,	1	13.05	21.01	–	–	2.75	–	–	7.24	–	–	.43	–	–	–	–	4.17	2.17	.32	–	–	–	4.17
Tobacco stalks weathered during winter and spring.	2	7.62	–	1.40	1.18	1.29	4.01	.52	2.26	.92	.38	.65	–	–	–	–	–	–	–	–	–	–	1.86
Tobacco stems,	10	9.10	20.91	2.72	1.99	2.03	8.68	3.88	6.36	1.15	.32	.63	–	–	–	–	6.49	–	–	–	–	–	1.58
Turf,	2	19.29	6.36	1.97	1.91	1.94	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vegetable mold,	1	26.07	–	–	–	.62	–	–	.66	–	–	.45	–	–	–	–	–	–	–	–	–	–	–
Water abstract of dry forest leaves,	1	99.46	.16	–	–	.004	–	–	.03	–	–	.022	–	–	–	–	.025	–	–	–	–	–	–
Wood and leaf mold,	1	68.94	4.90	–	–	.35	–	–	.05	–	–	.05	–	–	–	–	.19	–	–	–	–	–	–
(*e*) *Wool Products.*																							
Felt refuse,	1	29.34	33.53	–	–	5.26	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mill gloss,	2	9.43	–	13.16	12.22	12.69	–	–	.50	–	–	.20	–	–	–	–	–	–	–	–	–	–	6.50
Wool waste,	19	9.38	–	8.30	.39	3.60	5.92	.18	1.55	1.02	trace	.48	–	–	–	–	2.39	–	–	–	–	–	31.58
Wool washing, water from,	1	–	–	–	–	–	–	–	3.92	–	–	–	–	–	–	.49	.28	–	–	–	–	–	–
Wool waste and sheep manure,	1	7.13	–	–	–	2.63	–	–	2.20	–	–	.64	–	–	–	–	–	–	–	–	–	–	–
Wool dustings,	1	14.10	16.04	–	–	3.65	–	–	.29	–	–	.32	–	–	–	–	1.02	–	–	–	–	–	9.25
Wool washings acid,	1	–	–	–	–	–	–	–	4.20	–	–	–	–	–	–	.40	.61	.20	–	–	–	–	–
Wool washings alkaline,	5	90.67	3.28	.21	.03	.09	1.09	.13	.45	.12	.004	.04	–	–	–	.92	.48	.04	–	–	–	–	–

D. By-Products and Refuse Substances — *Concluded.*

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
(e) Wool Products — Con.																							
Wool washings and concentrated paste,	2	41.37	–	1.09	.93	1.01	13.38	10.15	11.76	.32	.10	.21	–	–	–	–	–	–	–	–	–	–	–
Wool washing, refuse from,	5	39.80	51.18	.44	.31	.38	.89	.41	.63	.18	.09	.12	–	–	–	–	1.29	–	1.66	–	–	–	47.02
Wool, raw,	1	6.95	7.54	–	–	12.88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.63
Wool scouring, dried refuse from,	4	3.51	–	8.20	1.52	3.60	3.52	.82	2.27	.52	trace	.20	–	–	–	–	–	–	–	–	–	–	30.40
(f) Miscellaneous Substances.																							
Dredging from Cape Cod,	1	18.99	–	–	–	.99	–	–	.13	–	–	.07	–	–	–	–	–	–	2.06	–	–	.54	–
Egg shells, ground,	1	1.15	73.30	–	–	1.19	–	–	.14	–	–	.38	–	–	–	–	47.47	–	–	–	–	–	.10
Feldspar,	2	.11	–	–	–	–	11.56	7.32	9.44	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Fleshings from tannery,	2	33.20	–	7.55	.85	4.20	–	–	–	.31	.12	.22	–	–	–	–	–	–	–	–	–	–	8.48
Garbage tankage,	1	2.12	–	–	–	5.95	–	–	–	–	–	6.06	–	4.40	1.66	–	–	–	–	–	–	–	–
Glass factory, refuse from,	1	16.48	–	–	–	–	–	–	19.50	–	–	–	–	–	–	6.12	–	–	–	–	–	–	–
Glue refuse,	1	28.03	11.67	–	–	1.90	–	–	–	–	–	.37	–	–	–	–	–	–	–	–	–	–	–
Granite,	3	.30	–	–	–	–	3.50	1.33	2.11	–	–	trace	–	–	–	–	trace	.11	19.53	–	–	–	70.25
Ivory dust,	1	11.50	52.63	–	–	6.64	–	–	–	–	–	24.56	.97	17.97	5.62	–	–	–	–	–	–	–	–
Lactate factory, waste from,	1	34.11	–	–	–	.68	–	–	–	–	–	.67	–	–	–	–	22.59	–	–	–	–	–	6.92

Leather, dissolved,	1	6.85	13.01	–	–	7.93	–	–	–	–	–	.18	–	–	–	–	–	–	–	–	–	–	–
Leather meal (raw),	2	8.75	2.08	7.72	5.76	6.74	–	–	–	–	–	.03	–	–	–	–	–	–	–	–	–	–	.17
Leather waste,	1	56.85	14.89	–	–	4.89	–	–	.20	–	–	.18	–	–	–	–	1.33	–	–	–	–	–	–
Lobster shells,	1	7.27	–	–	–	4.50	–	–	–	–	–	3.52	–	–	–	–	22.24	1.30	–	–	–	–	.27
Milk casein,	1	7.15	–	–	–	7.30	–	–	.76	–	–	8.06	–	–	–	–	11.78	–	1.40	–	–	–	.10
Oleomargarine refuse,	1	8.54	14.42	–	–	12.12	–	–	–	–	–	.88	–	–	–	–	–	–	–	–	–	–	.96
Paper mill dustings,	3	3.88	–	2.04	.35	1.23	.60	.44	.50	.17	trace	.10	–	–	–	–	1.15	–	4.40	–	–	–	11.70
Paper mill washings,	2	94.18	1.36	.18	.15	.16	.15	.14	.15	–	–	trace	–	–	–	–	.52	–	–	–	–	–	–
Paper mill, sludge from,	2	81.35	7.24	.33	.20	.27	.10	.06	.08	.56	.03	.29	–	–	–	–	2.91	–	–	–	–	–	1.84
Pillow manufacture, refuse from,	1	15.06	–	–	–	7.04	–	–	.41	–	–	3.17	–	–	–	–	–	–	–	–	–	–	–
Sea deposits,	1	43.82	–	–	–	1.06	–	–	.37	–	–	.19	–	–	–	–	–	–	–	–	–	–	–
Sewage,	4	54.11	72.89	1.04	.30	.55	.44	.09	.27	–	–	.63	–	–	–	–	2.79	–	–	–	–	.03	35.87
Sizing paste,	3	49.93	.49	2.13	1.13	1.49	–	–	–	.34	.02	.18	–	–	–	–	–	–	–	–	–	–	–
Sludge from filter beds,	4	48.35	17.70	1.07	.34	.66	.68	.05	.29	.33	.07	.24	–	–	–	–	5.48	–	–	–	–	–	19.84
Sludge from sewage tanks,	4	37.74	–	1.31	.46	.91	.66	.07	.25	.86	.39	.61	–	–	–	–	3.10	2.19	8.55	.41	4.86	–	28.70
Soap grease refuse,	2	29.25	51.39	4.20	2.21	3.21	–	–	–	15.37	11.04	13.21	–	–	–	–	–	–	–	–	–	–	1.29
Sponge refuse,	1	7.25	–	–	–	2.43	–	–	–	–	–	3.19	–	–	–	–	3.94	1.27	–	–	–	–	39.05
Tannery refuse from filter bed,	3	46.03	–	1.57	.18	.91	–	–	.10	1.58	.15	.86	–	–	–	–	20.58	.98	3.89	–	8.07	–	13.40
Tannery refuse from vats,	1	44.36	–	–	–	.64	–	–	.33	–	–	.11	–	–	–	–	1.67	–	–	–	–	–	36.07
Whale bone scrapings,	1	6.90	–	–	–	13.01	–	–	–	–	–	.26	–	–	–	–	–	–	–	–	–	–	–
Whale meat, raw,	1	44.50	1.04	–	–	4.86	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

E. Animal Excrements.

[Figures equal percentages or pounds in 100.]

Fertilizer Materials.	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Sodium Oxide.	Calcium Oxide (Lime).	Magnesium Oxide.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
Barnyard manure,	47	72.71	8.29	1.19	.18	.46	.92	.25	.55	.74	.10	.35	–	–	–	–	4.51	–	–	–	–	–	5.74
Compost,	1	1.70	–	–	–	.79	–	–	.97	–	–	.56	–	–	–	–	–	–	–	–	–	–	–
Dog manure,	1	6.50	–	–	–	1.91	–	–	.30	–	–	9.95	–	–	–	–	–	–	–	–	–	–	–
Drainage from manure heap,	1	93.20	3.66	–	–	.98	–	–	.88	–	–	.24	–	–	–	–	–	–	–	–	–	–	–
Duck manure (fresh),	1	61.62	–	–	–	1.12	–	–	.49	–	–	1.44	–	–	–	–	1.12	–	–	–	–	–	13.37
Goose manure (fresh),	2	57.99	–	1.12	.21	.67	.81	.51	.66	.95	.53	.74	–	–	–	–	.26	–	–	–	–	–	11.10
Guinea pig manure,	1	8.35	–	–	–	1.74	–	–	1.66	–	–	.55	–	–	–	–	.39	–	–	–	–	–	3.87
Hen manure (fresh),	8	65.14	–	2.30	1.07	1.56	.63	.42	.44	2.07	.50	1.09	–	–	–	–	1.62	–	–	–	–	–	10.20
Hen manure (dry),	1	5.66	–	–	–	2.08	–	–	1.01	–	–	1.68	–	–	–	–	2.72	–	–	–	–	–	–
Hen house refuse,	2	7.37	–	–	–	.71	–	–	1.03	–	–	1.02	–	–	–	–	–	–	–	–	–	–	71.07
Horse manure,	2	44.44	–	.74	.33	.54	2.82	.69	1.75	1.46	.21	.84	–	–	–	–	–	–	–	–	–	–	–
Liquid manure,	1	96.56	–	–	–	.56	–	–	.02	–	–	.01	–	–	–	–	–	–	–	–	–	–	–
Pigeon manure (fresh),	2	22.24	16.00	–	–	4.19	–	–	1.41	–	–	2.24	–	–	–	–	1.49	–	–	–	–	–	13.76
Poudrette, dry,	1	5.25	35.45	–	–	3.58	–	–	.49	–	–	5.74	–	–	–	–	–	–	–	–	–	–	4.65
Sheep manure, dry,	15	7.77	–	–	–	2.13	–	–	2.08	–	–	1.38	–	–	–	–	2.91	–	–	–	–	–	22.90

F. Analyses of Insecticides.

[Figures equal percentages or pounds in 100.]

	Analyses.	Moisture.	Arsenious Oxide As_2O_3.	Copper Oxide.	Arsenious Oxide As_2O_5.	Water Soluble Arsenic.	Lead Oxide.	Zinc Oxide.	Barium Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulfur.	Sulfuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxide.	Insoluble Matter in Hydrochloric Acid.
Barium arsenate (white arsenoid),	1	2.35	31.90	-	-	-	.96	-	48.31	-	-	-	-	-	3.19	-	-	-	-
Copper arsenite,	2	5.21	51.52	36.82	-	8.08	-	-	-	-	-	-	-	-	-	-	-	-	.09
Lead arsenate (dry neutral),	3	2.49	-	-	25.92	.25	68.19	-	-	-	-	-	-	-	-	-	-	-	.22
Lead arsenate (dry acid),	2	.50	-	-	30.21	.09	64.50	-	-	-	-	-	-	-	-	-	-	-	.04
Lead arsenate (waste from),	8	44.58	-	-	15.58	-	36.21	-	-	6.76	-	-	-	-	-	-	-	-	.06
Laurel green,	1	7.64	7.34	13.50	-	-	-	-	-	-	-	-	-	-	-	26.31	-	-	-
Lime arsenite,	1	.80	76.31	-	-	40.88	-	-	-	-	-	-	-	-	-	21.63	-	-	.02
Nicotina,	1	10.00	-	-	-	-	-	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Paris green,	27	.85	58.44	30.96	-	4.41	-	-	-	-	-	-	-	-	-	-	-	-	.21
Paris green (aceto copper arsenite,	2	1.12	56.65	31.34	-	1.46	-	-	-	11.95	-	-	-	-	-	-	-	-	.03
Paris green (collected during 1901),	14	.81	57.73	29.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrox,	1	58.09	-	4.21	6.79	-	16.35	-	-	-	-	-	-	-	-	5.27	-	-	-
Tobacco liquor,	1	37.71	-	-	-	-	-	-	-	-	2.12	-	-	-	-	3.07	6.55	.23	-
Tobacco liquor,	1	40.89	-	-	-	-	-	-	-	-	.53	-	-	-	-	1.47	16.34	.01	-

Table VI. — Compilation of Analyses of Fruits and Garden Crops.

H. D. HASKINS.

A. Analyses of fruits.
B. Analyses of garden crops.
C. Relative proportions of phosphoric acid, potassium oxide and nitrogen found in fruits and garden crops.

The figures in A and B are in parts per 1,000. To convert into percentages or pounds in 100, move the decimal point one place to the left.

Some of the following analyses were taken from the compilation of E. Wolff. Those marked with an asterisk (*) were made at the laboratory of the Massachusetts Agricultural Experiment Station.

The tables will be found suggestive when one is preparing fertilizer formulas for various fruit and garden crops. One has also to consider, however, in making such fertilizer mixtures, the influence of cultivation and crop rotation as well as the plant food in the soil.

Members of the clover family are not dependent wholly upon supplied nitrogen, they having the power, after a vigorous start, to acquire atmospheric nitrogen when plenty of potash phosphoric acid and lime are supplied. An excess of phosphoric acid may be used in formulas without danger of loss from leaching. The same is true, to a certain extent, in case of potash, although this element is more often found in a water-soluble form in soils than is phosphoric acid. The well-known system of crop fertilization advocated originally by Wagner is based upon the necessity of an abundant supply of potash and phosphoric acid in the soil, while the nitrogen is added in such limited amounts and at such times as will provide for the maximum growth of the crop and the minimum loss through leaching.

A. Analyses of Fruits.

Fertilizer Constituents of Fruits.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Ericaceæ: —										
*Cranberries,	996	–	1.8	.9	.1	.3	.1	.3	–	–
*Cranberries,	894	.8	–	1.0	–	.2	.1	.3	–	–
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	–
*Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	–	–
Cherries,	825	–	3.9	2.0	.1	.3	.2	.6	.2	.1
*Peaches,	884	–	3.4	2.5	–	.1	.2	.5	–	–
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	–

Fertilizer Constituents of Fruits — Concluded.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Rosaceæ — *Con.*										
Plums,	838	–	2.9	1.7	–	.3	.2	.4	.1	–
Strawberries,	902	–	3.3	.7	.9	.5	–	.5	.1	.1
*Strawberries,	–	–	5.2	2.6	.2	.7	.4	1.0	–	–
*Strawberry vines,	–	–	33.4	3.5	4.5	12.2	1.3	4.8	–	–
Saxifragaceæ: —										
*Currants, red,	871	–	4.1	1.9	.2	.8	.3	.9	–	–
*Currants, white,	–	–	5.9	3.1	.2	1.0	.3	1.1	–	–
Gooseberries,	903	–	3.3	1.3	.3	.4	.2	.7	.2	–
Viticeæ: —										
Grapes,	830	1.7	8.8	5.0	.1	.7	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

B. Analyses of Garden Crops.

Fertilizer Constituents of Garden Crops.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Chenopodiaceæ: —										
*Beets, red,	877	2.4	11.3	4.4	.9	.5	.3	.9	–	–
Beets, sugar,	750	1.4	6.0	2.3	1.4	.6	.5	.8	.2	.2
*Beets, sugar,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	–
Beets, sugar, leaves,	800	3.0	15.0	3.0	3.0	1.5	1.1	.7	.5	1.0
Beets, sugar, seed,	146	–	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9
Beets, sugar, tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Mangolds,	900	1.2	6.5	2.8	1.5	.3	.4	.6	.3	.9
*Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	–	–

Fertilizer Constituents of Garden Crops — Continued.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ — *Con.*										
Mangold leaves,	905	3.0	14.6	5.0	2.8	1.6	1.4	.8	.8	2.3
Spinach,	903	4.9	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
*Spinach,	922	3.4	9.6	9.6	2.1	.6	.5	.5	–	–
Compositæ: —										
Artichoke,	811	–	10.1	2.4	.7	1.0	.4	3.9	.5	.2
*Artichoke, Jerusalem,	775	4.6	–	4.8	–	–	–	1.7	–	–
Lettuce, common,	940	–	8.1	3.7	.8	.5	.2	.7	.3	.4
Lettuce, head,	943	2.2	10.3	3.9	.8	1.5	.6	1.0	1.1	.8
*Lettuce, head,	970	1.2	–	2.3	.2	.3	.1	.3	–	–
Lettuce, Roman,	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4

Convolvulaceæ: —										
Sweet potato,	758	2.4	7.4	3.7	.5	.7	.3	.8	.4	.9
Cruciferæ: —										
Cabbage, Savoy,	871	5.3	14.0	3.9	1.4	3.0	.5	2.1	1.2	1.1
Cabbage leaves,	890	2.4	15.6	5.8	1.5	2.8	.6	1.4	2.4	1.3
Cabbage, white,	900	3.0	9.6	4.3	.8	1.2	.4	1.1	1.3	.5
*Cabbage, white,	984	2.3	–	3.4	.3	.2	.1	.2	–	–
Cauliflower,	904	4.0	8.0	3.6	.5	.5	.3	1.6	1.0	.3
Horse-radish,	767	4.3	19.7	7.7	.4	2.0	.4	2.0	4.9	.3
Kohlrabi,	850	4.8	12.3	4.3	.8	1.4	.8	2.7	1.1	.6
Radishes,	933	1.9	4.9	1.6	1.0	.7	.2	.5	.3	.5
*Ruta-bagas,	891	1.9	10.6	4.9	.7	.9	.3	1.2	–	–
Turnips, white,	920	1.8	6.4	2.9	.6	.7	.2	.8	.7	.3
*Turnips, white,	895	1.8	10.1	3.9	.8	.9	.3	1.0	1.0	–
Turnips, white, leaves,	898	3.0	11.9	2.8	1.1	3.9	.5	.9	1.1	1.2

Fertilizer Constituents of Garden Crops — Continued.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Cucurbitaceæ: —										
Cucumbers,	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins,	900	1.1	4.4	.9	.9	.3	.2	1.6	.1	–
Gramineæ: —										
Barley, grains,	108	19.2	–	4.8	–	–	–	7.9	–	–
Buckwheat, grain,	134	17.3	–	3.0	–	–	–	6.9	–	–
Corn, kernels,	144	16.0	12.8	3.7	.1	.3	1.9	5.7	.1	.2
*Corn, kernels,	100	18.2	–	4.0	.3	.3	2.1	7.0	–	–
*Corn, whole ears,	90	14.1	–	4.7	.6	.2	1.8	5.7	–	–
*Corn, stover,	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	–	–
Corn, whole plant, green,	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5

*Corn, whole plant, green,	786	4.1	–	3.8	.5	1.5	.9	1.5	–	–
Hay, English,	140	12.6	–	16.1	–	–	–	3.2	–	–
Millet seed,	140	18.5	29.5	3.3	.4	.2	2.8	6.5	.1	.1
Oats, grain,	143	17.6	27.4	4.8	.4	1.0	1.9	7.4	.5	.3
Rye, grain,	87	18.1	–	5.8	–	–	–	8.6	–	–
Wheat, grain,	144	20.0	–	5.2	–	–	–	8.0	–	–
Leguminosæ: —										
Alfalfa hay,	68	24.7	–	17.9	–	–	–	6.1	–	–
Bean straw,	160	–	40.2	12.8	3.2	11.1	2.5	3.9	1.7	3.1
Clover, hay,	153	19.7	–	18.7	–	–	–	5.5	–	–
*Cow pea, green,	788	2.9	–	3.1	.6	3.0	1.0	1.0	–	–
Garden beans, seed,	150	39.8	27.4	12.1	.4	1.5	2.1	9.7	1.1	.3
Hay of peas cut green,	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	2.0
*Leaves and stems of velvet beans,	58.8	28.6	–	–	–	–	–	–	–	–
Peas, straw,	160	10.4	43.1	9.9	1.8	15.9	3.5	3.5	2.7	2.3
Peas, seed,	143	36.5	27.5	12.5	.2	1.1	1.9	10.0	.8	.4

Fertilizer Constituents of Garden Crops — Concluded.

[Parts per 1,000.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulfuric Acid.	Chlorine.
Leguminosæ: —										
*Small pea, dry (*Lathyrus Sylvestris*), .	90	38.5	–	25.7	4.7	17.9	5.0	9.0	–	–
Soy bean, seed, . .	100	53.4	28.3	12.6	.3	1.7	2.5	10.4	.8	.1
*Velvet beans, kernel, .	111.6	31.1	–	13.2	–	–	–	7.7	–	–
*Velvet beans, with pod,	115.2	19.6	–	13.1	–	–	–	8.4	–	–
Liliaceæ: —										
*Asparagus, . .	942	3.3	–	3.29	–	–	–	1.08	–	–
Asparagus, . .	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3
*Asparagus roots,[1] .	81.7	16.2	58.8	21.6	1.8	2.8	1.4	4.7	4.0	–
Onions, . .	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
*Onions, . .	892	–	4.9	1.8	.1	.4	.2	.7	–	–
Solanaceæ: —										
Potatoes, . .	750	3.4	9.5	4.0	.3	.3	.5	1.6	.6	.3
*Potatoes, . .	798	2.1	9.9	2.9	.1	.1	.2	.7	–	–

Potato tops, nearly ripe,	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe,	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
Tobacco leaves,	180	24.5	150.7	50.9	4.5	50.7	10.4	6.6	8.5	9.4
*Tomatoes,	940	1.7	–	3.6	–	.3	.2	.4	–	–
*Tobacco, whole leaf,	103.1	24.3	–	57.9	24.7	45.8	13.8	4.3	16.3	1.59
Tobacco stalks,	180	16.4	74.7	38.2	6.6	12.4	.5	9.2	2.2	2.4
*Tobacco stems,	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	–	–
Umbelliferæ: —										
Carrots,	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.2	.4
*Carrots,	898	1.5	9.2	5.1	.6	.7	.2	.9	–	–
Carrot tops,	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry,	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	–	–
Celery,	841	2.4	17.6	7.6	–	2.3	1.0	2.2	1.0	2.8
Parsnips,	793	5.4	10.0	5.4	.2	1.1	.6	1.9	.5	.4
*Parsnips,	803	2.2	–	6.2	.1	.9	.5	1.9	–	–

[1] Twenty-four analyses.

C. Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Fruits and Garden Crops.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Fruits.			
Ericaceæ: —			
*Cranberries,	1	3.0	–
*Cranberries,	1	3.33	2.66
Rosaceæ: —			
Apples,	1	2.7	2.0
*Apples,	1	1.9	1.3
Cherries,	1	3.3	–
*Peaches,	1	1.3	–
Pears,	1	3.6	1.2
Plums,	1	4.3	–
Strawberries,	1	1.4	–
*Strawberries,	1	2.6	–
*Strawberry vines,	1	.7	–
Saxifragaceæ: —			
*Currants, red,	1	2.1	–
*Currants, white,	1	2.8	–
Gooseberries,	1	1.9	–
Viticeæ: —			
Grapes,	1	3.6	1.2
Grape seed,	1	1.0	2.7
Garden Crops.			
Chenopodiaceæ: —			
*Beets, red,	1	4.1	3.3
Beets, sugar,	1	2.88	1.75

C. Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Chenopodiaceæ — *Con.*			
*Beets, sugar,	1	4.8	2.2
Beets, sugar, leaves,	1	4.28	4.28
Beets, sugar, tops,	1	2.3	1.7
Beets, sugar, seed,	1	1.5	–
Mangolds,	1	4.66	2.0
*Mangolds,	1	4.2	2.1
Mangold leaves,	1	6.25	3.75
Spinach,	1	1.7	3.06
*Spinach,	1	19.2	6.8
Compositæ: —			
Artichoke,	1	.63	–
*Artichoke, Jerusalem,	1	2.8	2.7
Lettuce, common,	1	5.3	–
Lettuce, head,	1	3.9	2.2
*Lettuce, head,	1	7.7	4.0
Lettuce, Roman,	1	2.3	1.8
Convolulaceæ: —			
Potato, sweet,	1	4.6	3.0
Cruciferæ: —			
Cauliflower,	1	2.3	2.5
Cabbage, leaves,	1	4.1	1.7
Cabbage, Savoy,	1	1.9	2.5
Cabbage, white,	1	4.1	1.7
*Cabbage, white,	1	11.0	7.6

C. Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Cruciferæ — *Con.*			
Kohlrabi, ...	1	1.6	1.8
Radishes, ...	1	3.2	3.8
Radish, horse, ...	1	3.9	2.2
*Ruta-bagas, ...	1	4.1	1.6
Turnips, white, ...	1	3.6	2.3
*Turnips, white, ...	1	3.9	1.8
Turnips, white, leaves, . . .	1	3.1	3.3
Cucurbitaceæ: —			
Cucumbers, ...	1	2.0	1.3
Pumpkins, ...	1	.56	.69
Gramineæ: —			
Barley, grain, ...	1	.61	2.43
Buckwheat, grain, . . .	1	.43	2.51
Corn, whole plant, green, . .	1	3.7	1.9
*Corn, whole plant, green, . .	1	2.2	2.8
Corn, kernels, ...	1	.6	2.8
*Corn, kernels, ...	1	.6	2.6
*Corn, stover, ...	1	4.4	3.7
*Corn, whole ears, ...	1	.8	2.5
Hay, English, ...	1	5.03	3.93
Millet, seed, ...	1	.51	2.84
Oats, grain, ...	1	.65	2.38
Rye, grain, ...	1	.67	2.10
Wheat, grain, ...	1	.65	2.50

C. Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops — *Continued.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Leguminosæ: —			
Alfalfa, hay,	1	2.93	4.05
Bean straw,	1	3.3	–
Clover, hay,	1	3.4	3.58
*Cow pea, green (*Dolichos*),	1	3.1	2.9
Garden beans, seed,	1	1.2	4.0
Hay of peas, cut green,	1	3.4	3.4
Peas, seed,	1	1.2	3.65
Pea straw,	1	2.8	4.0
Soy bean seed,	1	1.21	5.12
*Small pea, dry (*Lathyrus sylvestris*),	1	3.4	4.2
*Velvet beans, kernel,	1	1.7	4.0
*Velvet beans, with pod,	1	1.56	2.3
Liliaceæ: —			
*Asparagus,	1	3.05	3.06
Asparagus,	1	1.3	3.6
*Asparagus roots,[1]	1	4.60	3.45
Onions,	1	1.9	2.1
*Onions,	1	2.6	–
Solanaceæ: —			
Potatoes,	1	2.5	2.1
*Potatoes,	1	4.1	3.0
Potato tops, nearly ripe,	1	2.7	3.1
Potato tops, unripe,	1	3.7	5.3

[1] Twenty-four analyses.

C. Relative Proportions of Phosphoric Acid, etc., in Fruits and Garden Crops — *Concluded.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Solanaceæ — *Con.*			
Tobacco leaves,	1	7.71	3.71
*Tobacco, whole leaf,	1	13.46	5.65
Tobacco stalks,	1	4.15	1.78
*Tobacco stems,	1	10.7	3.8
*Tomatoes,	1	8.7	4.5
Umbelliferæ: —			
Carrots,	1	2.7	2.0
*Carrots,	1	5.7	1.7
Carrot tops,	1	2.9	5.1
Carrot tops, dry,	1	8.0	5.1
Celery,	1	3.5	1.1
Parsnips,	1	2.8	2.8
*Parsnips,	1	3.3	1.2

COMPOSITION OF SOME MASSACHUSETTS SOILS.

BY J. B. LINDSEY.

In the year 1892 samples of typical soils were taken from different parts of the State under the general supervision of Prof. William P. Brooks. Prof. Benjamin K. Emerson, the geologist of Amherst College, advised as to the most suitable location to secure some of the soils, in order that they might be representative. The soils were carefully analyzed under the direct supervision of the late Prof. C. A. Goessmann, and the completed results of each soil are here presented for the first time.

Description of Types.

Soil No. 1. — Ten inches surface soil taken on the grounds of the Massachusetts agricultural experiment station, north of Hatch barn.

Soil No. 2. — Ten inches surface soil taken on Agawam Plains, not cultivated for ten years.

Soil No. 3. — Twelve inches surface soil taken from hill pasture in Agawam. The soil known as Agawam red sandstone.

Soil No. 4. — Granite till from Dedham, locality of Fox Hill; 12 inches surface soil.

Soil No. 5. — Cranberry bog from Colony Stock Farm; 6 inches surface soil.

Soil No. 6. — Diked Salt Marsh, Marshfield; tide shut off twenty years ago; soil cultivated.

Soil No. 7. — Soil of alluvial formation from Hadley meadows; overflowed in 1862 and 1872, and a deposit of sand was left which injured it materially.

Soil No. 8. — Virgin soil, taken from South River salt marsh, Marshfield, Mass.

Soil No. 9. — Natural fresh-water meadow from Sudbury, Mass.; very wet.

Soil No. 10. — Gneiss till from Shutesbury, Mass.; very barren.

Soil No. 11. — Mica schist from Deerfield, Mass.; taken from base of hill. Virgin soil, good pasture land, never cultivated.

Soil No. 12. — Limestone till from Pittsfield, Mass.

Soil No. 13. — Copperas rock from Hubbardston. Virgin soil, very strong.

Analysis of Types of Massachusetts Soils.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.	No. 13.
Coarse materials (.5 mm.),	1.42	14.48	45.81	23.63	–	6.13	.05	–	–	26.26	14.92	18.03	44.36
Fine earth,	98.58	85.52	54.19	76.37	100.00	93.87	99.95	100.00	100.00	73.74	85.08	81.97	55.64
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ANALYSIS OF FINE EARTH.													
Insoluble matter,	80.38	86.68	73.89	76.48	9.25	72.45	82.42	78.31	9.49	82.68	77.83	81.05	70.39
Soluble silica,	2.41	1.73	7.57	3.88	–	1.15	1.78	2.11	.26	1.20	1.82	.78	.92
Potash (K_2O),	.38	.18	.30	.19	.16	.24	.22	.33	.53	.13	.40	.25	.46
Soda (Na_2O),	.29	.38	.46	.42	.34	.19	.21	1.63	1.78	.38	1.56	.96	.95
Lime (CaO)	.70	.68	.47	.41	.01	.68	.99	.36	1.71	.92	1.15	1.58	.50
Magnesia (MgO),	.26	.81	.90	.49	–	.72	.93	.19	.66	.19	.79	.34	.22
Manganese oxide (Mn_3O_4),	.06	.17	.13	.09	–	.05	.07	.06	.09	.06	.07	.07	.04
Ferric oxide (Fe_2O_3),	3.76	3.49	4.59	3.86	39	4.47	5.09	3.54	1.71	3.79	5.93	5.39	12.26
Alumina (Al_2O_3),	6.22	4.27	6.64	4.69		5.37	3.15	2.57	2.09	3.01	5.86	4.32	4.98
Phosphoric acid (P_2O_5),	.31	.10	.22	.06	.04	.24	.32	.13	.20	.20	.29	.29	.36
Sulfur trioxide (SO_3),	.15	.12	.12	.21	.38	.64	.27	.33	.71	.03	.05	.08	.05
Volatile matter,	4.88	2.08	4.37	9.81	89.76	14.42	3.83	9.89	80.13	6.89	4.45	4.92	8.72
Total,	99.80	100.69	99.66	100.59	100.33	100.62	99.28	99.45	99.36	99.48	100.20	100.03	99.85
Humus,	1.72	.46	.54	1.89	41.23	6.56	1.97	1.30	26.86	1.80	1.05	.87	1.46
Ash,	.406	.026	.199	.249	1.90	.443	.64	.22	.56	.275	.28	.23	.34
Phosphoric acid,	.079	.012	.032	.036	.027	.093	.145	.026	.11	.036	.053	.029	.026
Silica,	.107	.006	.084	.12	–	.228	.320	.144	.28	.124	.11	.12	.17
Nitrogen,	.20	.07	.09	.30	.27	.50	.11	.28	.43	.18	.12	.18	.155
Hygroscopic moisture,	5.38	3.69	10.69	7.40	26.29	14.85	3.81	20.66	36.78	5.200	4.25	8.88	14.54

According to Hilgard[1] "Virgin soils with high plant food percentages are always productive, provided, only, that extreme physical characters do not interfere with normal plant growth." By high plant food percentages is meant 1 per cent. of acid soluble potash, 1 of lime, the same or less of magnesia and .15 per cent. of phosphoric acid. In case there is a low percentage of one of the above elements, it is an indication that this will be the first to fail, and will have to be supplied in the form of farm-yard manures or chemical fertilizers. The total percentage of nitrogen in the soil is of less importance than the nitrogen percentage in the humus, of which there should be at least 4 per cent. to insure satisfactory production.

It will be seen that none of the above soils could be classed as highly productive, yet by comparing the analyses with the standards for average soils as given further on, it will be seen that, in so far as their chemical analysis is concerned, most of them would be capable of producing satisfactory crops.

Miscellaneous Soil Analyses.

From time to time during the last ten or fifteen years the station has had occasion to examine soils sent from different sections of the State. The following tabulation shows the percentages of the more important fertilizer constituents which they contained. The data concerning the history of each soil are not at present available. From our present knowledge of the value of chemical analysis in determining soil fertility it is doubtful if such data would have proved particularly helpful, so much depending upon the physical character of the soil and subsoil, drainage and the character of the crops to be grown. This matter is briefly referred to further on. In general it may be said that the soils were taken from the cultivated fields of Massachusetts farms.

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[1] Soils, by E. W. Hilgard, p. 343.

Table of Miscellaneous Soil Analyses (Per Cent.).[1]

Source.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Abington (garden?),	–	.85	.78	.44	–
Amesbury (reclaimed marsh),	6.21	1.41	.24	.36	–
Amherst (Massachusetts Agricultural College, productive),	–	.23	.26	.112	.06
Amherst (Massachusetts Agricultural College, unproductive).	–	.23	.16	.114	.07
Amherst (Massachusetts Agricultural College, experiment station).	–	.20	.16	.253	1.64
Amherst (Massachusetts Agricultural College, south acre),	–	.16	.13	.271	1.33
Amherst,	–	.48	.11	.36	.54
Amherst,	–	.18	.24	.17	.34
Amherst,	–	.08	.15	.07	.24
Amherst,	–	.11	.20	.15	.24
Amherst,	7.38	.21	.10	.21	.17
Amherst,	–	.16	.11	.28	1.04
Amherst,	–	.22	.07	.29	.73
Amherst,	–	.24	.11	.23	.67
Arlington (average of 3 samples),	–	.14	.15	.23	.80
Athol,	8.79	.27	.13	.11	.23
Barre (average of 3 samples),	–	.20	.25	.29	.65
Belmont,	8.57	.27	.21	.15	.12
Berlin,	–	.26	.14	.30	.46
Bernardston,	–	.12	.25	.20	.95
Bernardston,	–	.08	.15	.11	.15
Beverly,	–	.37	.30	.56	.56
Beverly,	–	.02	.22	.56	.50
Bisbees,	–	.21	.13	.25	.32
Boston,	6.02	.16	.205	.401	trace
Boston,	–	.35	.387	.26	1.17
Boston,	–	.13	.04	.09	.11
Boston,	–	.25	.26	.19	.13
Boston,	–	.11	.04	.11	.16
Boston,	4.25	.11	.04	.07	.55
Boston,	6.69	.20	.06	.01	.33
Boston,	6.04	.14	.06	.07	.21
Boston (near seacoast),	8.53	.47	.17	1.02	1.08

[1] Analyses made by H. D. Haskins and assistants.

Table of Miscellaneous Soil Analyses (Per Cent.) — Continued.

Source.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Brockton (greenhouse?),	–	.42	.19	.11	.69
Brookfield,	–	.47	.36	.29	.20
Brookline (greenhouse?),	–	.93	.23	.21	1.42
Brookline (greenhouse?),	–	.51	.07	.25	1.48
Cambridge,	–	.18	.29	.18	.77
Canton,	–	.30	.19	.23	.78
Clinton,	–	.22	.13	.15	1.52
Clinton,	–	.22	.24	.81	.65
Concord,	9.88	.48	.21	–	trace
Concord (asparagus),	4.30	.13	.24	.09	.22
Conway,	–	.24	.07	.17	–
Conway,	–	.44	.09	.21	–
East Holliston,	–	.19	.14	.14	1.00
East Whately,	–	.14	.25	.24	.16
East Whately,	–	.11	.34	.18	.19
East Whately,	–	.19	.09	.18	.10
East Whately,	–	.12	.32	.49	.69
East Whately,	–	.08	.18	.53	.85
Florence (tobacco),	2.24	.81	.98	–	1.79
Florence (tobacco),	–	.96	.37	–	1.12
Foxborough,	9.47	.28	.08	.10	.63
Foxborough (average of 7 samples),	–	.21	.25	.16	1.19
Framingham,	–	.17	.34	.23	.56
Framingham,	–	.13	.13	.13	.24
Gloucester (low and swampy; reclaimed),	–	.86	.60	.74	1.00
Greenfield,	–	2.42	.30	.30	3.57
Hadley,	–	.15	.49	.24	.49
Hadley (mill pond basin),	–	.17	.08	.56	.82
Halifax (average of 6 samples),	12.18	.28	.03	.09	.26
Halifax (average of 2 samples),	–	.66	.31	.22	2.88
Halifax,	–	.10	.09	.26	.75
Hampden,	–	.20	.23	.13	.39
Hampden,	–	.41	.30	.08	.46
Harding,	–	.14	trace	.12	.30

Table of Miscellaneous Soil Analyses (Per Cent.) — Continued.

Source.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Harding,	–	.12	trace	.11	.41
Harding,	–	.17	.04	.13	.24
Harding,	–	.14	trace	.17	.33
Haverhill,	–	.17	.45	.20	1.30
Haverhill (meadow, 3½ feet),	72.60	1.61	.09	.12	1.01
Haverhill (bank of river),	–	.51	.21	.13	.32
Holliston,	–	.20	.22	.25	1.00
Hubbardston,	–	.26	.12	.39	1.88
Lenox,	–	.07	.39	.28	1.41
Lenox,	9.18	.29	.23	.32	.10
Lenox,	–	.28	.34	.33	.85
Lenox,	–	.30	.17	.26	1.20
Lynn,	–	.39	.40	.32	1.51
Longmeadow,	–	.34	.20	.21	.54
Malden (garden soil),	12.57	.64	–	.49	.79
Mansfield (average of 3 samples),	–	.16	.15	.13	1.28
Mattapoisett,	–	.19	.20	.11	.73
Merrick,	–	.13	.35	.29	.79
Monson,	8.46	.24	.03	.21	.10
Montague (corn experiment plat),	–	.16	.13	.37	1.41
Newbury,	–	.26	trace	.16	.15
Newbury,	–	.28	.13	.15	.29
Newbury,	–	.28	.16	.23	.17
Newbury,	–	.28	.29	.15	.11
Newbury,	–	.29	.17	.15	.15
Newton,	–	.18	.01	.23	.59
Newton,	–	.18	.01	.23	.59
Newton,	–	.23	.07	.13	.76
Newton,	–	.22	.01	.14	.42
Newton,	–	.26	.08	.14	.82
Newton,	–	.22	.01	.14	.42
Newton,	–	.38	.23	.22	.85
Newton,	–	.10	.15	.22	1.19
Newton Highlands,	7.42	.31	.18	.16	–

Table of Miscellaneous Soil Analyses (Per Cent.) — Continued.

Source.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Newton Highlands,	–	.34	.07	.50	.65
New Bedford (average of 6 samples),	–	.24	.14	.25	.53
Northampton (average of 3 samples),	–	.14	.19	.39	1.00
North Adams,	–	.60	.36	.89	2.41
North Adams,	–	.23	.14	.62	.40
North Adams,	–	.25	.10	.55	.30
North Eastham (asparagus farm),	–	.22	.05	.07	.58
North Easton,	–	.12	.09	.21	–
North Easton,	–	.19	.24	.20	–
North Weymouth,	–	.35	.10	.34	.67
North Weymouth,	–	.32	.32	.25	.71
Norton,	–	.18	.05	.09	.75
Norton (average of 3 samples),	–	.14	.15	.09	.84
Orange,	–	.20	.11	.28	.38
Orange,	–	.44	.20	.20	.49
Plymouth,	–	.15	.10	.18	.50
Rutland (sanatorium),	–	.20	.16	.25	.09
Scituate,	–	.33	.13	.10	.16
South Carver,	–	.06	.08	.19	.23
South Carver,	–	.10	.29	.59	.48
South Carver,	–	.11	.31	.39	.27
South Framingham (average of 6 samples),	6.89	.22	.14	.19	.47
Springfield,	–	.16	.18	.22	.57
Springfield,	–	.15	.16	.16	.55
Springfield,	–	.39	.14	.48	1.32
Sunderland,	14.09	.64	.70	.49	.54
Swift River,	–	.23	.09	.23	.17
Taunton,	–	.34	.23	.22	trace
Tewksbury (average of 2 samples),	6.93	.36	–	.29	.64
Truro,	–	.19	.24	.27	.81
Upton (carnation soil),	–	.41	.44	.20	.64
Upton (carnation soil),	–	.23	.69	.23	.83
Upton (carnation soil),	–	.50	.81	.46	.60
Waltham (greenhouse?),	–	.76	.40	.47	.83

Table of Miscellaneous Soil Analyses (Per Cent.) — Concluded.

Source.	Organic Matter.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Calcium Oxide.
Webster,	1.25	–	.03	–	–
Wellesley,	–	.28	.66	.28	1.77
Westfield,	–	.29	.25	.31	.95
Westminster,	–	.32	.13	.30	.28
West Newton,	–	.14	.25	.16	1.14
West Springfield (average 14 samples),	–	.25	.51	.36	.97
Weymouth,	5.69	.24	.11	.24	.34
Whately,	–	.12	.02	.58	1.07
Whately,	–	.13	.20	.36	.94
Williamstown,	–	.27	.21	.37	.18
Winter Hill,	6.39	.27	.18	.23	.92
Worcester,	–	.29	.07	.45	1.23
Worcester,	–	.14	.05	.20	1.57

European Standards for Comparison (Hilgard).[1]

Practical Rating of Soils by Plant Food Percentages.[2]

Grade of Soil.	Potash.	Phosphoric Acid.	Lime.		Total Nitrogen.
			Clay Soil.	Sandy Soil.	
Poor,	Below 0.05	Below 0.05	Below 0.10	Below 0.05	Below 0.05
Medium,	0.05–0.15	0.05–0.10	0.10–0.25	0.10–0.15	0.05–0.10
Normal,	0.15–0.25	0.10–0.15	0.25–0.50	0.15–0.20	0.10–0.15
Good,	0.25–0.40	0.15–0.25	0.50–1.00	0.20–0.30	0.15–0.25
Rich,	Above 0.40	Above 0.25	Above 1.00	Above 0.30	Above 0.25

In case of the above analyses of Massachusetts soils, the potash percentage varies from .01 to 1.02, with an average of .26; the phosphoric acid from .01 to .98, with an average of .21; the lime from .06 to 3.57, with an average of .71, and the nitrogen from .02 to 2.42, averaging .30.

[1] Soils, p. 343.

[2] According to the late Prof. Max. Maercker of the Halle Station, Germany.

Judging from such results most of the soils can at least be classed as normal from a chemical standpoint, some of them good and a few rich. Practically all of them are quite suitable for crop production if properly handled. One, however, would not care to say, from a chemical analysis alone, whether any one of them was suited to a particular crop, so many other conditions entering into the problem. Brooks, in Circular No. 29 of this station, has made this matter clear, as follows: —

1. *The Crop Adaptation.* — While the chemical condition of a soil is not altogether without influence in determining the crops to which it is suited, this, as a rule, at least within such range of soil variation as exists in this State, plays a much less important part than mechanical and physical peculiarities. The crops to which a soil is suited are determined chiefly by its drainage, its capacity to hold and to conduct water, its temperature and its aëration, and these in turn are determined by the mechanical structure of the soil and sub-soil. Variations in the proportions of gravel, sand, silt and clay, and not in chemical composition, cause the usual differences in these respects. The varying proportions of these, therefore, usually determine the crops to which a soil is suited.

2. *Fertilizer Requirements.* — The results of a chemical analysis of a soil do not, as a rule, afford a satisfactory basis for determining manurial requirements. The chemist, it is true, can determine what the soil contains, but no ordinary analysis determines with exactness what proportion of the several elements present is in available form for the crop. Indeed, there is no such thing as a constant ratio of availability. While one crop finds in a given soil all the plant food it requires, another may find a shortage of one or more elements. Further, on the very same field one crop may find an insufficient amount of potash; another may find enough potash for normal growth, but insufficient phosphoric acid; while a third may suffer only from an insufficient supply of nitrogen.

Most of our soils are of mixed rock origin, and, as a rule, possess similar general chemical characteristics, providing they have been farmed under usual conditions. The manurial and fertilizer requirements are determined more largely in most soils by the crop than by peculiarities in the chemical condition of the soil.

3. *Crop Diseases.* — The chemical composition of the soil may in some instances exercise a controlling influence in determining a condition of health or disease, and is never unimportant from the standpoint of vigorous, normal and healthy growth; but in the case of most diseases, the immediately active cause is the presence of a parasitic fungus, and this fungus is usually capable of fixing itself upon the

plant, whatever may be the composition of the soil. A knowledge of the chemical composition of soils, therefore, will not make it possible to advise such manurial or fertilizer treatment as will insure immunity from disease.

Conditions under which Analyses will be made.

For the reasons which have been briefly outlined, the chemical analysis of soils does not, as a rule, afford results which have a value commensurate with the cost; and this station, therefore, will not make such analysis unless the soil differs widely from the normal in natural characteristics, or has been subjected to unusual treatment of such a nature as to probably greatly influence its chemical condition. In order that we may decide whether analysis seems called for, correspondents are urged to write before taking samples, and when doing so to state all the conditions as fully as possible. This statement should include a full description of the soil and as full a report as possible as to the manures and fertilizers applied and crops raised for a number of years previous to the date of writing. In all cases in which, on the basis of the information given, it appears that a chemical analysis promises results of value, such an analysis will be made, and for the present free of charge; but, as explained in the preceding paragraphs, such analyses appear to be only rarely worth while. It will usually be possible to give helpful advice in relation to the use of manures and fertilizers on receipt of a full statement as to the character and history of the soil and the crop which is to be raised, and such advice will always be gladly given.

In case analysis is regarded as desirable, full directions for taking and forwarding samples will be sent.

INDEX.

INDEX.

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TWENTY-THIRD ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART II.,

BEING PART IV. OF THE FORTY-EIGHTH ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

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TWENTY-THIRD ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART II.

GENERAL REPORT OF THE EXPERIMENT STATION.

CONTENTS.

Part II.

MASSACHUSETTS
AGRICULTURAL EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

TWENTY-THIRD ANNUAL REPORT.

Part II.

SUMMARY OF LEADING CONCLUSIONS.

WM. P. BROOKS, DIRECTOR.

The papers included in this part of the annual report cover a wide variety of subjects, and many of them are of such a character that the conclusions cannot be briefly stated. A full list of the papers is included in the table of contents, and in cases where deemed desirable the principal sub-topics are included. The papers themselves are concise, and should be read in full by those interested in them. Some of the more important conclusions may be stated as follows: —

1. Profitable hay crops may be produced in permanent mowings by top-dressing with fertilizers only.

2. A combination of slag meal and a potash salt produces hay made up chiefly of Kentucky blue grass and white clovers. The addition of nitrate of soda in amounts varying from 150 to 200 pounds per acre is usually profitable. The hay produced ranks exceptionally high in nutritive value, especially where the slag meal and potash only are used.

3. The use of slag meal and low-grade sulfate of potash is strongly recommended as a top-dressing for pastures. In experiments continuing two years it has profoundly modified the character of the herbage, the most striking change being a re-

markable increase in the proportion of white clover. It is estimated that the amount of feed now produced is at least three times as great as that on the part not top-dressed.

4. Experiments and observations lead to the conclusion that alfalfa can be successfully grown in Massachusetts. Experiments with the crop are urged. The type of soil, and the method of fertilization and sowing believed to be best are described.

5. It has been found that either excelsior or sawdust first saturated with creosote and packed about the joints of drain tiles prevents the entrance of roots, while at the same time the treatment seems to protect the materials used from decay.

6. The conditions under which roots are likely to penetrate drain tiles are described, and observations are presented which indicate under what conditions the roots of trees are found to be particularly dangerous.

7. Spraying shade trees by the methods first perfected for fruit trees is found to be exceedingly costly. The equipment essential both for satisfactory work and to insure the least possible cost is described. Briefly, powerful machinery capable of maintaining a pressure of 200 to 250 pounds per square inch and special types of nozzles are recommended.

8. Some of the more important of the agencies acting unfavorably on our shade trees are described. The more important are contact with wires of telephone, electric light and trolley lines, putting in of water mains and gas pipes, marked deficiency in rainfall and severe climatic conditions. These appear to have caused extensive root killing and gradual death of the trees, while both sun scald and sun scorch have seriously injured some species. The methods of distinguishing between injuries due to the several causes are carefully presented.

9. The fact that the chestnut disease seems to be gaining a foothold in Massachusetts is stated, and the localities are mentioned where it has been found. It is suggested that the unfavorable condition of the trees due to climatic causes may have rendered them peculiarly susceptible. Owners of chestnut lumber of merchantable size where the disease is found are advised to cut at once.

10. The extent to which crown gall affects fruit trees, and the nature and probable seriousness of the disease are dis-

cussed. The importance in the purchase of nursery stock of securing trees from localities free from this disease is urged.

11. The occurrence of a fusarium disease of cucumbers and allied plants, the first symptom of which is wilting which usually results in the death of the plant is pointed out. This at present affects chiefly hothouse crops, but in some localities is found in out-door crops. In the case of hothouse crops, excessive crowding and forcing seem to produce plants with tissues peculiarly susceptible. Growers are advised against such treatment.

12. The fact that large numbers of fruit trees of all kinds are in unsatisfactory condition due to unfavorable climatic causes, and the presence of San José scale is pointed out. The gradual death of the feeding roots due to the excessive drought and extreme cold, the presence of sun scald often followed by canker are among the more important results. Methods of treatment are suggested.

13. The essential features of a satisfactory nozzle for spraying, especially the larger trees, are described; and briefly stated, the most essential points appear to be the capacity to throw the material long distances and yet to break it into a mist-like spray. A nozzle believed to be a great improvement on any type previously made is described and illustrated.

14. The general character, digestibility and the best methods of use of distillery and brewery by-products are stated, and rations for different classes of farm animals are suggested.

15. The composition, digestibility and feeding value of apple pomace lead to the conclusion that if used in a balanced ration about four pounds of the pomace will equal in value one pound of good hay.

16. The minimum digestible protein needed daily by a cow weighing 1,000 pounds and yielding 20 pounds of milk is about 1.4 pounds; but an increase of about 35 to 50 per cent above this amount seems likely to yield profitable returns. For a 900 pound cow giving 12 quarts of milk per day about 1.8 pounds of digestible protein in the feed daily should be satisfactory. An increase in the protein above the minimum does not appear to affect the composition of the milk.

TOP-DRESSING PERMANENT MOWINGS.

BY WM. P. BROOKS, DIRECTOR.

Between the County Road and that portion of the college estate where the dormitories stand lies an area of about 30 acres which is treated as a part of the campus. It is crossed by numerous foot paths and portions of it are occasionally used for company or battalion drill. The surface is rolling and the soil of somewhat variable character; for the most part, however, it is a strong retentive loam, well suited for grasses and clovers. The greater part of this area has certainly not been plowed during the past twenty-two years and probably not for a considerably longer period. It was in 1889 that the writer of this article first became responsible for its management. At that time much of it had the appearance so common throughout New England of a somewhat neglected mowing, although it was much more productive than such mowings usually are. The prevalent species of grass were Kentucky blue and sweet vernal. In places there was considerable orchard grass, and meadow fescue was abundant especially in the moister places. Whiteweed (Chrysanthemum leucanthemum) was extremely abundant in all the drier portions. Dandelions, buttercups and common plantain were very abundant in places. Some portions of this area have been plowed and reseeded during the period intervening since 1889, but on most of it an effort has been made both to eradicate the weeds and to improve the product both in quality and quantity by top dressing without plowing and reseeding. This seemed desirable in view of the preference of college authorities to treat this area like a campus rather than as farm land.

The most effective method for the eradication of the whiteweed has been found to be early cutting to prevent ripening of seed, and top dressing with materials favorable to the

clovers and grasses. In such portions of the area as have been plowed and reseeded, it has always been found that we had a crop of whiteweed to contend with. Undoubtedly the soil, formerly rather indifferently managed, like that of so many of the New England farms, is heavily stocked with seeds of this as well as of many other weeds, and every time it is turned over conditions have been made right for the germination of some of those which have previously been buried too deeply to germinate.

The statement of the conditions affecting this area must have made it apparent that they do not afford a satisfactory basis for close comparison on limited areas. The total area involved, however, is so large that the unequalities and disturbing conditions which have been referred to are somewhat equalized and it was therefore thought to be worth while a few years since to undertake comparisons between different fertilizer combinations with a view to affording at least object lessons on the possibilities of modifying and improving the herbage in permanent grass land by varying use of fertilizers.

General Plan.

In each of the principal sections into which the area is naturally divided by roads and principal walks, a few half-acre sections were laid off and throughout the period of the experiment, which is now some six years, these have received no fertilizer whatever. In two of the natural subdivisions of the area, plots of substantially one-half acre each have been laid off and these throughout the entire period have been fertilized annually with nitrate of soda only at the rate of 150 pounds per acre.

On the balance of the entire area basic slag meal has been applied annually at the rate of 500 pounds per acre. This on different sections of the area has been used in connection with the different leading potash salts as follows: —

(1) On that portion of the area lying north of the "Cross Walk" so-called, the potash salt used is muriate at the rate of 150 pounds per acre.

(2) On that portion of the area south of the Cross Walk

an l west of the college pond and the stream which runs into it, high grade sulfate of potash is used at the rate of 150 pounds per acre.

(3) On the balance of the area which lies south of the Cross Walk and east of the college pond and stream, the potash salt used is the low grade sulfate at the rate of 300 pounds per acre.

With each of these differing combinations we are applying nitrate of soda on about one-half of the total area to three substantially equal plots. The rates respectively are 150, 200 and 250 pounds per acre.

Owing to the large area covered by these experiments, and the varying conditions as to weather, often showery, in which hay must be handled, it has been found difficult to obtain weights which are strictly comparable. The general results have, however, been clearly apparent, and the following figures, based upon such weights as have been taken during the past three years, in a measure indicate what they have been.

1. Slag Meal and Muriate of Potash both with and without Nitrate of Soda.

In the section of the field where these fertilizers have been used, the yields on the plots to which no fertilizer has been applied have varied between 867 and 1,833 pounds per acre. The average for the past three years has been 1,419 pounds per acre.

Top-dressing with slag meal and muriate of potash produced an increase in crop which has varied during the past three years from 1,588 to 1,902 pounds per acre. The average increase has been at the rate of 1,714 pounds per acre. The total crop produced where slag meal and muriate of potash have been applied as top-dressing has averaged 3,133 pounds per acre.

The gain resulting from top-dressing with nitrate of soda at the rate of 150 pounds per acre in connection with the slag and muriate of potash has varied between 557 and 1,205 pounds per acre.

The use of 200 pounds of nitrate of soda per acre has produced an increase varying from 543 to 2,775 pounds, the average for the past three years being 1,419 pounds per acre.

The use of 250 pounds of nitrate of soda per acre in connec-

tion with slag and muriate of potash has produced an increase varying from 736 to 2,265 pounds per acre, the average being 1,283 pounds per acre.

The figures above given have all referred to the first crop. In years characterized by normal rainfall these fields have always produced a moderate crop of rowen, but the past two seasons have been so abnormally deficient in rainfall that the rowen crops have been small, — in some years, indeed, so small that the fields have not been cut. The amount of rowen produced on plots where nitrate of soda is used in connection with the slag and potash has been less than where the slag and potash alone have been used. This difference, it will be readily understood, is due to the fact that clover is relatively more abundant on those portions of the field where slag and potash alone are applied.

2. Slag Meal and Low-grade Sulfate of Potash both with and without Nitrate of Soda.

It has so happened that we have but few weights that can be regarded as entirely reliable pertaining to the results on the field where these fertilizers are employed; but examinations of the fields at various times have shown that the result of the employment of slag and low-grade sulfate of potash alone has been a remarkable increase in the proportion of white clover, which has attained a height and luxuriance that the writer has seldom seen equaled. The increase in crop resulting from the application of this combination of fertilizers has clearly been large. The employment of nitrate of soda in connection with slag and low-grade sulfate of potash in amounts varying from 150 to 250 pounds per acre on different plots has resulted in a very small increase.

3. Slag Meal and High-grade Sulfate of Potash both with and without Nitrate of Soda.

In one section of the field the plots top-dressed with slag and high-grade sulfate of potash have given a yield of hay during the past three years varying from 2,732 to 3,866 pounds per acre, the average being 3,351 pounds per acre.

In this field nitrate of soda is used on one plot in connection with the slag meal and high-grade sulfate of potash at the rate of 200 pounds per acre. This has given an increase, as compared with the plots to which the slag and potash alone are applied, varying from the insignificant amount of 26 pounds to 3,375 pounds per acre in one year. The average increase for the three years was at the rate of 1,479 pounds per acre.

In another section of the field slag meal, high-grade sulfate of potash and nitrate of soda in three different amounts have been applied. The increases produced during the past three years have been at the following rates per acre: —

For the slag, high-grade sulfate of potash and 150 pounds of nitrate of soda per acre, 2,730 to 4,220 pounds, the average being 3,279 pounds.

For the slag, high-grade sulfate of potash and 200 pounds of nitrate of soda per acre, 2,460 to 2,960 pounds, the average being 2,710 pounds.

For the slag, high-grade sulfate of potash and 250 pounds of nitrate of soda per acre, 2,080 to 5,470 pounds, the average being 3,747 pounds.

General Observations on Results.

The character of the vegetation has been greatly influenced by the system of management which has been followed. The most marked effects are the following: —

(1) The amount of white weed produced has greatly decreased in all portions of the field which have been top-dressed, and especially on those which have been top-dressed without replowing. The same is true, though to a somewhat less extent, concerning the buttercups and plantain. The dandelions, which come up very early in the spring, before the grasses and clovers have made much growth, are still relatively abundant.

(2) On those parts of the field which have not been top-dressed bluets (*Houstonia cœrulea*) are becoming increasingly abundant, while the yield of hay has become very small, usually varying between 1,000 and 1,500 pounds per acre.

(3) On all parts of the field top-dressed with a combination of slag meal and a potash salt, the clovers have become very

abundant. They appear to be somewhat less abundant on the muriate of potash than on the sulfates, and there seems to be a difference in the relative proportions of white and red clovers on the two sulfates, the former being relatively most abundant on the low-grade sulfate, while the red clover has been most luxuriant on the high-grade sulfate of potash. It should be remembered, in estimating the significance of this observation, that no seeds of any kind have been sown in these fields; and it is further important to keep in mind the fact that the soil conditions, as has been indicated, vary quite widely in different portions of the area under consideration. It may be, therefore, that the differences in proportion of white and red clovers just referred to are due either to accidental conditions or to variations in soil, and not to the difference between these two salts.

(4) The use of slag and either of the potash salts produces on the average an increase in the crop considerably more than sufficient to pay the cost of top-dressing with these materials. The results demonstrate the ability of soils naturally adapted to grass to produce profitable hay crops without frequent replowing.

(5) Close observation of the crops produced and of the general conditions prevailing leads to the conclusion that these fields are improving from year to year. The proportion of weeds is decreasing, while that of clovers is increasing.

(6) The use of nitrate of soda in connection with slag meal and a potash salt usually gives a considerable increase in the hay crop, in most cases more than sufficient to pay the cost; but an application at the rate of 250 pounds per acre appears to be in excess of requirements. If the season is characterized by normal or abundant rainfall, the crops receiving nitrate of soda at this rate almost invariably lodge badly, and, as a result, the yields are somewhat lessened. During years with abundant rainfall, nitrate of soda at the rate of 150 pounds appears to give as much increase in the crop as is produced by nitrate in any larger amount, and while the yield on 200 pounds sometimes exceeds that produced by the lesser amount, it is the writer's belief that the 150-pound rate for mowings similar to

those under consideration will usually be found most profitable.

(7) The proportion of clover on those portions of the field receiving nitrate of soda in connection with slag meal and a potash salt is somewhat less than where the slag and potash salt are used alone, but the product is still characterized by a liberal proportion of clovers.

(8) The product of these fields has exceptionally high nutritive value. The hay is made up of a large variety of grasses, principally Kentucky blue grass, sweet vernal and fescues, with considerable orchard grass in some portions of the fields. It contains, as has been pointed out, a very large proportion of clover, and it contains also a considerable proportion of a number of different species, some of which have been mentioned, commonly looked upon as weeds. It will be recognized that such a product would not ordinarily sell well in the markets. It is, however, exceptionally palatable to cattle, and it has been noted again and again that milch cows, when receiving it in connection with liberal grain rations, give a considerably larger yield of milk than when fed on the best of mixed timothy, red top and clovers in connection with similar grain rations. This difference seems usually to amount to about 10 per cent. more milk on the product of these permanent mowings. The superintendent of the college farm, who during the past year or two has had some experience in feeding good alfalfa hay to milch cows, and who is a close observer, has recently stated that he believes the product of these old fields to be superior to the best alfalfa hay as a food for milch cows.

The facts to which attention has just been called lead to the conclusion that where the production of hay for market is the object, such a system of management as is used in these fields is not likely to give satisfactory results, but where hay is to be fed to stock on the farm, especially to cows or sheep, the system has much to commend it under certain conditions.

It is not infrequently the case that certain of the fields of the farm lie at such distances from the farmstead that their use in the production of hoed crops is impracticable. It is out of the question to haul manure to them. The conditions affecting

farm labor may render it rather impracticable to break them up and reseed them frequently. Under such conditions, such fields as we are considering on many farms are simply neglected. The product of hay soon sinks to less than a ton to the acre and hardly pays the cost of cutting. For such fields the system of top-dressing with slag meal and a potash salt, either without nitrate of soda or in connection with a small amount of that material is likely to be profitable.

Method of applying Fertilizers.

In the experiments to which reference has been made, the fertilizers have invariably been applied in spring, and this will probably, as a rule, be the best season. It should be the rule to make the application at about such time as grass fairly begins to grow, and this in average seasons will usually be between about the 20th of April and the 1st of May.

TOP-DRESSING PASTURES.

BY WM. P. BROOKS, DIRECTOR.

The results obtained in top-dressing the permanent mowings, which comprise a large proportion of the college campus, have demonstrated most conclusively that the character and growth of the forage produced may be profoundly modified by the nature of the fertilizer applied. It was early noticed that the continued, moderate use of basic slag meal and a potash salt had a marked effect upon the proportion of clovers, and therefore upon the nutritive value of the hay produced. This hay is made up largely of Kentucky blue grass and white clover, and is found to be much superior as forage for milch cows to the best grades of hay (composed of timothy, red top, alsike and red clovers) produced in our rotation mowings, these mowings being usually cropped two years in corn and then from two to four years in hay.

These observations led to the belief that similar systems of top-dressing would prove highly beneficial to many of our pastures. These, as is generally recognized, are often of very inferior character. On the average, several acres are required to yield pasturage for a single cow, and this even in the case of pastures free from brush or other obstructions. In the Connecticut valley, especially, in the month of May, when the young grasses and clovers should be making a vigorous growth, producing rich green turf, it is common to find pastures almost as white as the driven snow with a thick crop of bluets (*Houstonia cærulea*), while the grasses are making little growth and white clover is scarcely to be found. In many cases close examination shows areas where mosses are replacing the grasses. Such conditions indicate a sour soil, and such pastures will produce relatively little feed.

In the spring of 1909 an experiment in top-dressing was

begun in one of these pastures in the northern part of the town of Amherst, on the farm of Herbert S. Dickinson. The portion of the pasture selected was level and entirely free from brush and stones. It is land which was under cultivation a considerable number of years ago. The soil is made up principally of the finest grades of sand and silt, and is quite retentive of moisture. The amount of feed produced in recent years had been small, and the pasture presented the characteristics above referred to in their most typical development.

Four plots of equal area in a part of the pasture, seemingly of very even quality, were laid off. Plots 1 and 3 received an application of basic slag meal and low-grade sulfate of potash (sulfate of potash-magnesia), mixed together before spreading at the following rates per acre: basic slag meal, 500 pounds; low-grade sulfate of potash, 300 pounds. Plots 2 and 4 were left untreated. The materials referred to were applied in the early spring. Before the end of the first season there was a marked difference in the character of the growth upon the fertilized and unfertilized plots. On the former, white clover was found to be coming in, while the grasses showed a much greener color and more vigorous growth.

The pasture in which these plots lay was heavily stocked with milch cows throughout the summer, and it was observed that they grazed upon the top-dressed plots a much larger proportion of the time than on the untreated plots, or the other portions of the pasture.

In the spring of 1910 the top-dressing of plots 1 and 3 was repeated. The differences of the previous season which have just been referred to became still more marked, and the preference of the cows for the forage produced on these plots became yet more noticeable. As a result of the superior character of the forage produced on the top-dressed plots, and the preference of the cows for feeding upon them, they were kept much more closely grazed throughout the entire season, and were especially far more closely grazed late into the autumn than is favorable to the best development. It is fair to suppose, therefore, that the fertilizers applied would have produced yet more marked effects under more favorable conditions. In

spite of these facts, however, the change in the character of the herbage, shown by examination early in the month of May, 1911, is nothing less than astonishing. In place of the dull, lifeless, moss-infested turf, thickly starred with bluets, we find in these plots a rich, green turf, in which white clover is much the most prominent species. Indeed, so thick is the clover in these plots that in most places it constitutes a perfect mat. This change, it should be pointed out, is the result simply of such modification of the soil conditions as fits it for clovers, for no seed of any kind has been sown. It can safely be inferred that the plots which have been top-dressed are now producing fully three times the amount of feed produced by those which have not been so treated.

From the description of the conditions under which this experiment has been tried it will be recognized that no figures can be presented which will indicate the extent of the improvement produced. An experiment is now being laid out in which two plots of equal area, one to be top-dressed and the other not, will be separately enclosed, and a record of the number of days of pasturage each affords will be kept. It will be understood that until we have this record it is not possible to state whether the improvement referred to has been produced at such cost as to make the system of top-dressing followed financially profitable. It is the belief of the writer, however, that it must have been so.

Conditions under which likely to be profitable.

The fact has been referred to that a large proportion of our pastures is producing relatively little feed. Whether they can be profitably improved by top-dressing is an important question. In a great many of our pastures improvement by top-dressing is the only practicable method, since, owing to the conditions existing, it is impossible to plow them. Not all pastures, however, are in such condition that top-dressing can be advised. It is not believed it will be found profitable except in those cases where the turf is mostly free from foreign growths, such as shrubs, bushes, hardhack (spirea) and ferns. If any considerable proportion of the area is occupied by such foreign

growths, the first step in improvement should be their removal. It has been common among our farmers to cut such vegetation in their pastures from time to time. My observation convinces me that this treatment is usually disappointing in results. At whatever season of the year such vegetation is cut it is likely to spring up again, and it may be cut year after year for a long series of years and still not be exterminated. While the initial outlay is, of course, much heavier, results ultimately much more profitable and satisfactory will, in my judgment, be obtained by uprooting bushes, etc., at the outset of any efforts towards improvement. When cleared of foreign vegetation a pasture may, in many cases with advantage, be harrowed and seeded if the surface is much broken as the result; but if the obstructions have been widely scattered, it may be advisable simply to level the areas dug up in connection with the removal of the foreign vegetation and to seed those areas only. Kentucky blue grass and white clover will be more useful than any other varieties, and will, I think, as a rule be the only kinds desirable. After the surface has thus been cleared, such pastures, as well as those which are now clear, may be expected to repay judicious top-dressing.

It may be here pointed out that improvement of our pastures will not only increase the amount of stock which a farmer can keep, but it will be likely to increase the milk yield of a given number of cows, since in improved pastures the animals will be able to gather sufficient food in a much smaller number of hours, and will have leisure to ruminate, and to convert a larger portion of the feed consumed into milk.

In pastures in which the surface is occupied in considerable measure by rocks, top-dressing is of course likely to prove less profitable than in those which are free from such obstructions. It will be apparent, further, that the more nearly level the pasture the less probability that the materials used in top-dressing will be washed away.

Materials used in Top-dressing.

It is believed that the basic slag meal used in the experiments referred to is peculiarly suited to meet the requirements of a

large proportion of our pasture soils. Especially must this be true of those naturally poor in lime, with soils which are retentive of moisture, and where white clover is scantily produced. Slag meal is likely to produce less striking effects in pastures which now produce white clover abundantly, or in those having excessively dry soils. Its special fitness for the improvement of pastures deficient in lime and not now producing white clover is undoubtedly connected with the fact that it is rich in lime. Its tendency, therefore, is to sweeten soils which are naturally sour, and thus to bring them into condition such that clovers can thrive. It is now generally understood that clovers cannot flourish in soils containing free acid. Basic slag meal, moreover, is a relatively low-priced fertilizer, and it may be pointed out still further that it has for many years been profitably used for top-dressing pastures in various parts of Europe, especially in England.

A potash salt, as well as the slag meal or some substitute for the latter, will in almost all cases be required, for without a liberal supply of potash in the soil clovers will not thrive, and a good permanent pasture without white clover is, in our climate, practically an impossibility. There are several potash salts which might be used. Most important among these are the muriate, the high-grade sulfate and the low-grade sulfate. In the experiments described the latter has been employed. The writer was led to select it chiefly because of his observations upon the results of top-dressing with the different potash salts in the permanent mowings referred to at the beginning of this article. It appears to be peculiarly adapted to bring in white clover; but observations upon the permanent mowings, where the different potash salts are under comparison, show that either the muriate or high-grade sulfate also will increase the proportion of white clover. These salts cost rather less in proportion to the actual amount of potash they supply than the low-grade sulfate, and in localities where transportation counts as an especially important item they should perhaps be preferred, since to obtain an equal amount of potash it would be necessary to use them in only half the quantities required of the low-grade sulfate. The writer would, however, call attention to the fact

that the latter supplies a large amount of magnesia as well as potash, and that it is not unlikely that this, while inferior to potash in its effects upon clover, may nevertheless exert an influence favorable to its more vigorous development.

Season for Top-dressing.

For level pastures it is the writer's belief that top-dressing with a mixture of slag meal and a potash salt had best be done in the autumn, but in all cases where the slopes are excessive it will be preferable to apply the materials in the early spring.

ALFALFA IN MASSACHUSETTS.

BY WM. P. BROOKS, DIRECTOR.

As time passes the number of successful experiments with alfalfa in Massachusetts increases. This is true not alone of the experiments in progress on the station grounds and on the college farm in Amherst, but of experiments which have been conducted by private individuals in various parts of the State as well. The question may arise, Why is the degree of success attending such experiments at present greater than in the case of the earlier experiments? It is the belief of the writer that the answer is, Because we have learned, as a result of our failures and successes, many things to avoid, and what conditions are best calculated to insure success. We now have very little difficulty in securing good catches of alfalfa, and on the station grounds and on the college farm in Amherst are a number of plots of some five or six years' standing which are yet in good condition; so that it would seem that we have not only learned what steps to take to secure a good catch, but also how so to manage as to insure a reasonable degree of permanence.

The writer would not be understood that he is as yet prepared to endorse too exclusive dependence upon alfalfa as a forage crop. He believes that there is still a considerable element of risk, but that at least the crop is worth careful trial.

Number of Crops per Year and Yield.

Alfalfa makes a more rapid growth in early spring than any other forage crop, unless it be rye. The first crop is usually ready to cut early in June, and at least two additional crops may be counted upon; while in seasons which are exceptionally favorable as to rainfall and other climatic conditions alfalfa may probably be safely cut four times. With three crops per

acre, which number has been the rule here, our yields in good fields have ranged from about 3¾ to 5¾ tons per acre of well-made hay for the three. Such yields are greater than those which can usually be counted upon from the clovers, or mixtures of grasses and clovers, and since in nutritive value alfalfa considerably exceeds the product of the ordinary hay field, such a yield indicates that the crop, where successful, is of unusual value.

Conditions essential to Success with the Crop.

Topography. — Experience and observation convince the writer that fields which have a moderate slope are to be preferred to those which are nearly level. Their superiority is due to the fact that it is relatively easy, in preparing for the crop, to leave the surface of such fields in such shape that water cannot possibly stand upon any part of them, and therefore that ice will never form on the surface. Ice on the surface of an alfalfa field is sure to destroy it, and as it is almost impossible to avoid places which are slightly depressed below the ordinary level, from which there is no outlet, in fields which are nearly level, slopes should be preferred.

Soil. — Alfalfa will succeed upon a considerable variety of soils provided certain conditions exist. First and most important of these is good drainage. The writer is convinced that it would not be advisable to undertake the cultivation of alfalfa in fields in which the water table will usually be found within less than five or six feet of the surface. It is possible that a fair degree of success might be obtained with the water table from three and one-half to four feet below the surface; but in all cases where the water table is at this level the percentage of water in the surface soil is likely to be relatively large, unless the soil is of exceedingly coarse texture; and with too large a percentage of water in the surface soil heaving and winter-killing will be more probable than on soils with less moisture at the surface. What has been said suggests that the necessary depth of the water table below the surface may vary somewhat with the texture of the soil above it. Where this is coarse the water table nearer the surface than the extreme depth above in-

dicated may not be productive of injurious consequences, since the capacity of the soil to conduct and to retain moisture is relatively small.

On the other hand, although alfalfa is a very deep-rooted plant, observation during the past two years, which has been characterized by exceptionally small rainfall, leads to the conclusion that it is quite sensitive to the injurious effects of extreme drought, and that soils and sub-soils of excessively coarse texture, with a water table far below the surface, can hardly be expected to give satisfactory crops. Soils which would be ranked as well adapted to grasses and clovers, provided the drainage conditions are such as have been indicated, seem likely to give the most satisfactory crops of alfalfa.

Necessity for Lime. — Alfalfa is a lime-loving crop. Success in producing it is impossible if the soil is poor in this element. The soils in many parts of this State are characterized by relative deficiency in lime, and in most localities, therefore, a moderate application of lime is necessary in preparing for alfalfa. The quantity needed will usually range between one and one-half and two tons per acre. There are a number of different forms of lime which may be made to serve the purpose. On the heavier soils freshly slaked lime or fine-ground lime will best meet requirements, since these forms of lime will at the same time improve the mechanical condition and correct the chemical faults. On the lighter soils, of coarser texture, and especially if these are deficient in organic matter, air-slaked lime or marl may be preferable. For the ordinary loams some of the various forms of so-called agricultural lime, or waste lime which has slaked in heaps at the kilns, will meet the requirements.

Fertilizer Requirements. — Alfalfa, in common with other legumes and clovers, does well only when there is a liberal supply of potash in available forms in the soil, and potash fertilizers should be freely used in preparing for alfalfa.

While the crop seems to depend in most marked degree upon an abundance of lime and potash in the soil, it is not indifferent to a supply of other plant food elements, and if the soil is not

naturally abundantly stocked with phosphoric acid, this element must be furnished.

A large amount of nitrogen in the soil cannot be regarded as essential; indeed, from some points of view it is undesirable; but, on the other hand, unless there is a fair amount of nitrogen in available forms in the soil the crop will fail to make a good start. When well established under the right conditions it can, like other legumes, draw the needed nitrogen from the air.

The application of manure to soils which are to be used for alfalfa in preparing for the crop will, it is believed, in general be found inadvisable. Manure, it is true, helps to give the soil the desired texture, and increases the proportion of humus which may be beneficial, but it usually carries many weed seeds, and increases the difficulty of getting a good catch of alfalfa. A free use of manure will, moreover, be likely to increase the competition of the grasses with the alfalfa, enabling these in a measure gradually to crowd the latter out. Manure used rather liberally for crops which immediately precede alfalfa, may, on the other hand, prove quite beneficial, especially on the lighter and poorer soils.

Seeding to Alfalfa.

Season for Sowing. — Success with alfalfa has been obtained both by early spring and summer sowing. In the experiments which the writer has carried out the latter has given the best results. If alfalfa is spring sown, it is commonly necessary to sow a nurse crop with it. If this is not done it must, in almost all soils, suffer greatly from the competition of annual weeds which tend to come in so freely in all fertile soils during the spring months. In the one case, then, it must share the soil with a nurse crop, in the other with weeds, and in either case the competition for plant food and moisture is somewhat unfavorable. Further, whether weeds grow up with the crop or whether a nurse crop is sown with it, the alfalfa, when these are removed, is exposed to the intense heat of the sun in midsummer, and if at this time there is a deficiency of rainfall, it almost invariably suffers a serious check.

When alfalfa is sown later in the summer it is possible to sow it alone, since by preparatory tillage the annual weeds, which tend to come in during the early part of the season, can be destroyed. Under these conditions the alfalfa is likely to make a better start than when it must meet the competition either of weeds or a nurse crop. The showers which almost invariably come in midsummer will give, in all except soils of very coarse texture, such moisture conditions as to insure quick germination of the seed.

Preparation of the Soil. — The essentials in the preparation of the soil are such tillage operations as will produce a fine seed bed and such application of fertilizers as will supply the natural deficiencies. It is a great mistake to sow alfalfa in imperfectly prepared ground. The seed bed should be as perfect as possible, and no amount of labor which is essential to produce a fine surface tilth should be spared. While the selection of fertilizers and the amounts of the several materials to be used should of course be varied to suit varying conditions, the writer recommends, as likely to prove satisfactory in the majority of cases, the following kinds and amounts per acre: —

Lime or marl, ...	1½ to 2 tons.
Basic slag meal, ...	1,500 to 2,000 pounds.
High-grade sulfate of potash, ...	250 to 300 pounds.
Nitrate of soda, ...	100 to 125 pounds.

The following method of applying the fertilizers is recommended: —

(1) Apply the lime on the rough furrow and disk in.

(2) Mix together the potash and all except about 200 pounds of the slag meal, apply after disking the land once and work in deeply by further disking or harrowing.

(3) Just before the final harrowing-in preparation for the seed, mix together the 200 pounds of slag meal and the nitrate of soda, and spread this evenly and harrow it in.

In case the alfalfa is to be spring sown, apply the lime in the autumn, and if convenient apply the mixture of slag meal and potash also in the autumn, although this is less essential. It may be applied, if preferred, just before the first disking in the spring.

In the case of summer sowing, apply the lime in the early spring and immediately disk it in. A little later apply the mixture of basic slag meal and potash and disk or harrow this in deeply, and spread the nitrate of soda and 200 pounds of slag before the last harrowing.

Nurse Crops for Spring Sowing. — For nurse crops for sowing with alfalfa in spring beardless barley and oats are among the best, barley being the safer nurse crop of the two, as it is far less liable to lodge. Whichever of the two crops is selected, the amount of seed should not be too great. A bushel of barley or a bushel and a half of oats to the acre will usually be sufficient.

Preparation for Summer Sowing. — It is sometimes possible to secure good conditions for summer sowing on land used the same season for the production of a crop; but it is desirable, if this is undertaken, that the crop be one permitting of absolutely clean culture, and which can be harvested not later than about the middle of July. In the case of all soils not already highly productive and in good tilth, a summer fallow, with most careful tillage in preparation for alfalfa, is highly desirable. The very best results which have been obtained in the writer's experience have followed this method of preparation. The land is plowed in early spring, the lime and fertilizers applied as indicated above, and thereafter the soil is worked with the harrow at intervals sufficiently frequent to destroy the successive crops of weeds which are likely to start. The frequency of harrowing advisable must, of course, vary with conditions, but will usually be once in about ten days to two weeks.

Alfalfa is sometimes sown in late summer in fields of growing corn, and sometimes the results by this method are satisfactory. In the States of the middle west, where it has been most largely tried, there have been numerous failures. It is, perhaps, needless to say that if this method is to be tried the corn should not be planted over thick, its cultivation should be level and most thorough, and in fertilizing for the corn crop the needs of the alfalfa which is to be sown later in the summer must not be overlooked.

Date of Sowing. — In spring sowing, alfalfa should be put in just as early as the soil can be brought into condition. For

summer sowing the best conditions will usually occur about July 25 to August 10. If sowing is deferred much later than the middle of August, the alfalfa does not get sufficiently well rooted nor make sufficient growth to go through the winter successfully. When sown about the last of July the crop frequently attains a height of a foot before cold weather, and should on no account be cut, as this growth is needed for winter protection.

Alfalfa Seed.— No pains essential to procuring the best possible seed should be spared. Numerous varieties of alfalfa have been introduced and extensively tried in different parts of the country, and a number of them have been under trial in this experiment station. So far, however, as the experiments of the writer enable him to judge, none of the newer varieties appears to be superior to the common type of alfalfa as cultivated in our northwestern States. Northern-grown seed, bright, heavy, free from impurities of all kinds, and especially free from dodder (a parasite which, if present in any amount, will destroy the crop), should be looked for. The seeds of dodder are extremely minute, and will be easily overlooked by the casual observer. The dealer should be asked to guarantee freedom from seed of this parasite, and in all cases of doubt samples should be sent to the experiment station for examination.

Quantity of Seed. — As is the case with all farm seeds, the quantity which may wisely be sown varies with conditions, and should be greater in proportion as these are unfavorable. With the best conditions for germination, and with seed of the best quality, about 25 to 30 pounds per acre should be sufficient. A thick stand of plants is, however, of the very highest importance. When the alfalfa is thin, weeds, grasses and clovers come in, and the latter especially tend to crowd the alfalfa out. It is the belief of the writer that the quantity of seed should therefore, even under the best soil conditions, be not less than 30 pounds to the acre, and in seeding with corn it would seem to be advisable to use from 5 to 8 pounds more.

Inoculation. — It is now generally understood that legumes have the capacity to take nitrogen from the air only in partnership with bacteria which live in nodules on their roots. These

bacteria are not ordinarily present in soils where alfalfa has not previously been grown. A possible exception is afforded by soils where sweet clover (*Melilotus alba*) is indigenous and abundant. This plant, however, is comparatively rare in Massachusetts, and in almost all cases, therefore, it is advisable to bring in the appropriate alfalfa bacteria by inoculation. Two methods may be followed: —

(1) Soil from a well-established alfalfa field where root nodules are abundant may be worked into the soil where the seed is to be sown. The quantity needed will range between about 300 and 400 pounds per acre. Care should be taken that soil which is to be so used be not long exposed to the light nor allowed to dry excessively. It should be spread, if possible, towards night or on a cloudy day, and immediately harrowed in.

(2) A culture may be used. A number of different artificial cultures are now produced and recommended for the inoculation of the different legumes. The United States Department of Agriculture sends out a material known as "Nitroculture." This is in fluid form. An American agency of a European company produces and offers a jelly-like culture known as "Nitragin." A New Jersey company sends out a culture known as "Farmogerm," which is also a jelly-like material. The writer's recent experience has been mainly with the latter, and the results have been satisfactory. Full directions for the use of cultures accompany every package, and these should be exactly followed.

Diseases of Alfalfa.

The only disease which has been serious in the experiments in growing alfalfa in this State is a species of rust or leaf-spot. This seems to be most likely to affect newly sown areas. The spots referred to are yellow in color. They are likely to appear first on the lower leaves of the plant; but in cases of bad infection the trouble rapidly spreads from leaf to leaf, and the entire foliage of the plant soon becomes yellowish in color and the leaves begin to fall. If the disease is allowed to take its natural course the plants, especially if young, are greatly enfeebled. Grasses and clovers under these conditions in many fields will be likely to displace the alfalfa.

No preventive treatment is known, but the disease can be checked and a healthy growth re-established by the simple process of cutting. This should be the rule whenever alfalfa, young or old, begins to show leaf-spot abundantly, and when the trouble is rapidly spreading towards the upper leaves it is best to cut at once. If the field is newly sown, and the crop only a few inches high, the cutting should not be too close to the ground. What is cut may be allowed to lie where it falls. Should the growth which follows in turn become infected, the trouble should be met in the same way, that is, the alfalfa should be recut.

In the case of an established field of alfalfa, if leaf-spot has become abundant the crop had best be cut and fed, or made into hay at once, even although the alfalfa may not have come into bloom.

Harvesting Alfalfa.

Alfalfa should usually be cut while in early bloom. If the stems close to the root be examined at this time it will be found that they carry buds which are beginning to develop. This indicates that it is ready to make a second crop. If allowed to stand much beyond the period of early bloom the plants start much less promptly after being cut, and the total yield of the season will be relatively small.

The last cutting in any season should not be too late. It is desirable that there should be a considerable growth remaining on the field for winter protection.

Alfalfa may sometimes, with advantage, be fed green; it has been successfully ensiled, but, as is the case with other legumes, the resulting silage is strong in flavor and not wholly satisfactory. It is preferable in most cases to make the crop into hay.

After cutting, alfalfa should be allowed to lie, with possibly one turning, until it is wilted. It should then be put into windrows and then into cocks, where it should be allowed to remain until cured. Hay caps are very desirable; indeed, almost a necessity for entirely satisfactory results. The length of time which alfalfa must remain in the cock will vary greatly with the weather. If this is showery or rainy it of course cures

slowly, in which case, in order to avoid injury to the plants below, the cocks should be moved. It is desirable, as in the case of clover, which is often similarly handled, to remove the caps and open and turn over the cocks on the morning of a good day, when it is judged to be sufficiently cured to be put in.

Top-dressing Alfalfa.

If the crop has been successfully inoculated, and the nodules which have been referred to are abundant on the feeding rootlets of the plants, it is not ordinarily necessary to top-dress with materials furnishing nitrogen; or at least, if such materials are at all required, as may be the case upon soils which are naturally very poor and light, they should be used only in moderate quantities.

Top-dressing with manure cannot as a rule be recommended, for this will increase the tendency of grasses and clovers to come in. It is better to depend upon chemical fertilizers, and in order to secure large crops for a series of years the more important mineral elements of plant food must be supplied in abundance. The following mixture of materials is recommended, per acre, annually: —

	Pounds.
Basis slag meal,	1,200 to 1,500
High-grade sulfate of potash,	250 to 350

Or, in place of the latter, low-grade sulfate of potash, 500 to 700 pounds. This mixture may be applied either in the autumn or in very early spring.

Secondary Value of Alfalfa.

Alfalfa, when successful, as has been pointed out, is not only a valuable forage crop, furnishing large yields of highly nutritious forage in proportion to area, but is also a crop of much importance because its introduction will mean much improvement in the soils on which it is grown. Wherever alfalfa is successfully cultivated the soils are sure to be rendered more productive. This improvement is a consequence, first, of the

deep sub-soiling due to the penetration of the great tap roots of the plant; and second, to the accumulation of nitrogen in the roots and stubble, drawn in the first instance from the air. It will be understood that when an alfalfa sod is plowed, and the roots and stubble decay, the large amount of nitrogen which they contain becomes available to succeeding crops.

EXPERIMENTS RELATING TO THE PREVENTION OF THE CLOGGING OF DRAIN TILE BY ROOTS.

BY G. E. STONE AND G. H. CHAPMAN.

For the past three years experiments have been carried on in our conservatory for the purpose of studying the effects which various antiseptic substances would have in preventing roots of different kinds from entering drain tile. The clogging of drain tile by roots is a serious matter, many drains being rendered useless in a short time. The only remedy in such cases is to dig up the tile, clean it out and lay it over again. This is expensive and unsatisfactory in any case, particularly so with sewer pipes or the drainage tile under steam-heating conduits.

Our experiments were carried on in different ways. In one series we buried 3-inch Akron tile vertically in boxes containing soil. The lower ends of these tile were cemented and the tile filled with water to the joints. The joints were then calked with various antiseptically treated fibers, and the antiseptic substances with which the joints were treated proved quite effective in preventing the access of roots to the tile.

Another method consisted in growing various plants in small pots, the bottoms of which were filled with chemically treated fibers. The pots were then filled with soil and planted with different seeds. It is well known that plants when grown in small pots soon fill the soil with roots, which seek new sources of supply by passing through the hole at the bottom of the pots. Our experiments were arranged in such a way that the roots, in order to accomplish this, would have to pass through or around the chemically treated fibers, and the ability of these fibers to prevent root development constitutes a test of their efficiency. This method proved quite satisfactory. After a

year or two trial of the above method we devised another, which has also proved to be very satisfactory. This consisted in growing plants in boxes, the bottoms of which were covered with wire netting. Over the wire there was spread about an inch of variously treated or untreated fibers, as some checks were left in these experiments. The boxes were then filled with soil in which various plants were grown. They were placed over large trays filled with water, a space being left between the bottom of the wire and the surface of the water for the purpose of observing the roots. The object of this test, as before, was to determine what substances would prevent roots from penetrating into the water below.

Results of Pot Experiments.

These experiments were started in the spring of 1908 and were conducted along the lines previously described; that is differently treated fibers were packed into the bottom of common flower pots for the purpose of determining what effect they would have on root penetration.

About 1 inch of the fiber was packed in 4-inch pots. In some of the pots the fiber was packed rather tightly and in others laid in loosely. On top of the fiber were placed 3 or 4 inches of soil and clover and grass seed sown; in some cases willow cuttings and other plants were also used. Several series of pot experiments were conducted. In all cases the pots were placed in saucers or in galvanized iron trays containing about half an inch of water, although the pots were watered occasionally from the top.

The substances used in these pot experiments and the treatment given are as follows: —

Excelsior and creosote.
Excelsior and Carbolineum.
Sawdust and creosote.
Sawdust and Carbolineum.
Asbestos and creosote.
Asbestos and Carbolineum.
Asbestos and arsenate of soda.
Oakum and creosote.
Oakum untreated.
Cocoa fiber and creosote.

The excelsior was the ordinary kind used for packing, and when boiled with creosote absorbed it very readily. A coarse sawdust, principally pine, was used in these experiments. Ordinary asbestos fiber was used, and the oakum came in large masses, and was the same as that used by plumbers in calking joints. Cocoa fiber is a refuse product from the manufacture of fiber mats, and was obtained from the Heywood Manufacturing Company, Boston. It has occasionally been recommended for mulching plants. In all cases these fibers were boiled for a long time in creosote or whatever medium was used. They were then air dried before using. The excelsior before being used was chopped up into a finer condition, so that it would pack more closely in the pots. The cocoa fiber and the asbestos did not take the creosote to any great extent, both being practically failures in this respect, and the oakum did not take it as well as the sawdust and the excelsior, which proved to be the best in this respect.

The results of this series of experiments in pots may be summarized as follows: —

The untreated oakum had no appreciable effect in checking root development, the roots growing unharmed in the oakum and penetrating through the bottom of the pots into the water below.

The oakum treated with creosote did not entirely prevent the roots from passing through the oakum to the bottom of the pot. Many of the roots, however, were browned and dead where they came in contact with the treated oakum. The nature of the oakum was such that a less degree of compactness was maintained than in any other of the substances.

Asbestos treated with arsenate of soda had no appreciable effect, the roots penetrating the treated fibers freely, due undoubtedly to the solubility of this compound in water.

The asbestos and creosote treatment was more effective, and few if any roots extended through the pots, although there was a healthy root development extending for some distance into the fiber.

Cocoa fiber treated with creosote did not prevent root development to any great extent, the roots penetrating freely unharmed through the bottom of the pot.

Sawdust treated with creosote proved to be one of the best substances for checking the development of the roots. In all but a few cases the roots in direct contact with the sawdust were killed, although in one instance, where the sawdust was not compacted enough, one root developed along the side of the pot without being injured. Where the sawdust was well compacted in the pots all the roots which came into contact with it were killed.

The excelsior and creosote were fully as effective as the sawdust. The excelsior, however, being more loosely compacted, allowed some roots to penetrate further into it before being killed than was the case with the sawdust, but in no case did any of the roots penetrate through or around the excelsior through the hole in the bottom of the pot.

Not quite as good results were obtained from the use of excelsior and Carbolineum and sawdust and Carbolineum as with excelsior and creosote and sawdust and creosote. Both the excelsior and sawdust retained the creosote the best, as was evident from the color and odor as well as from the results of root killing and penetration. A greater compactness of both the sawdust and excelsior would undoubtedly prove even more effectual in preventing root growth.

The substances, arranged as regards their degree of efficiency, may be grouped as follows: —

Excelsior and creosote.
Sawdust and creosote.
Excelsior and Carbolineum.
Sawdust and Carbolineum.
Cocoa fiber and creosote.
Asbestos and creosote.
Oakum and creosote.

The sodium arsenate treatments were all failures, as this substance seemed to wash out very quickly, and in one case, where asbestos was treated with creosote, 40 per cent. of the roots passed through the hole in the bottom of the pot.

No better results were obtained with asbestos and Carbolineum.

Cocoa fiber failed to absorb and retain the chemicals any

length of time. For this reason it was unsatisfactory. However, in some experiments a large percentage of roots were killed when they came in contact with this substance, especially when the creosote was retained by the fibers.

The creosoted and untreated oakum did not prove of much value.

There was little difference between the excelsior and sawdust treatment; one was about as good as the other, although the excelsior was easier to manipulate. On the other hand, the sawdust was more compact, and this was in its favor. Creosote in these tests appeared to be slightly superior to Carbolineum, but the latter would be an excellent substance for this purpose.

Experiments in Boxes.

A. — Experiments in boxes provided with vertical tile, with one end plugged, have been carried on for two years. In these boxes were grown tomatoes, grass and willows. The boxes were 14 by 14 by 14 inches, and contained about 1 foot of soil. A vertical 3-inch Akron tile extended to the bottom of the boxes, the joints being 4 inches below the surface of the soil. The bottoms of the tile were plugged with cement and the tile was kept filled with water to the level of the joints. One tile was placed in the middle of each of the four boxes, the joints being treated with the following substances: —

Sawdust and creosote.
Excelsior and creosote.
Cocoa fiber and creosote.
Oakum untreated.

The results of this experiment are as follows: —

The treated sawdust prevented any roots from penetrating the tile, and when there was any attempt made to penetrate the treated substance, the roots turned brown and died.

The creosoted sawdust appeared as good as when first applied, and was characterized by a strong creosote odor.

The results of treatment with excelsior and creosote were practically the same as those with sawdust. In a few cases, however, roots forced their way along the tile to the joint. The

roots which attempted to grow in excelsior were browned and dead. The results obtained from the use of cocoa fiber and creosote were not nearly as good as the two preceding ones. The roots penetrated the fiber and came through into the water. About 35 per cent. of the roots which penetrated the fiber were alive and healthy.

The results obtained from the untreated oakum showed that it had little effect, the roots appearing to be healthy, and not at all injured by this substance.

B. — The experiments described here were made in three boxes, each being 14 inches wide, 22 inches long and 14 inches high. The bottoms of these boxes were covered with $\frac{1}{4}$-inch mesh galvanized wire. On each wire in one-half of each box there was placed about 1 inch of sphagnum, the other half being covered with some treated material. Box No. 1 had sphagnum 1 inch thick in one end and the same amount of excelsior treated with creosote in the other end. Box No. 2 was likewise provided with untreated sphagnum in one end, the other being filled with sawdust treated with cement. Box No. 3 was treated in the same way as No. 1. These boxes contained about 12 inches of soil, and rested on galvanized-iron trays containing 2 inches of water. A space of about half an inch, however, was left between the bottom of each box and the water in the tray for the purpose of observing the roots. Several crops of tomato and tobacco plants and grass were grown in these boxes, with the results that none of the roots had penetrated through the treated substances into the water in the tray, whereas in every case where untreated sphagnum was employed the root penetration was invariably common.

The results obtained from these various methods of treatment show that it is possible at the present time to prevent root growth by the use of certain chemical substances. Our results seem to indicate, also, that these various treatments possess a lasting effect, and that chemically treated fibers could be used in a practical way to prevent the clogging of drain tile. In these experiments it must be borne in mind that a vast number of roots come in contact with the treated substances, and that ordinarily if these substances had not been there thousands of roots

would have developed and occupied the space given up to the treated fibers; and probably in all cases a large number of the roots would have penetrated through the bottom of the pots into the water below. In only a very few instances did any of the roots in the experiments where creosote was used penetrate to any depth where sawdust and excelsior were used. Practically all the penetration occurred close to the surface of the pot, where the chemically treated fibers were packed rather loosely, and especially in those experiments where excelsior was used.

A more or less thorough calking of the joints of Akron tile with either creosoted excelsior or sawdust would undoubtedly prevent the occurrence of roots in the joints, and consequently in the tile itself. Some sewer pipes have been calked with these chemically treated fibers, but it is as yet too early to state how effectually they may have accomplished their purpose. Akron tiles, or those provided with flanges, are best adapted to treatment. Ordinary land drain tiles, however, are not provided with flanges, and it is a question whether root penetration could be successfully prevented by using these fibers, at least by placing them loosely over the joints. It would be possible and no doubt practicable, however, to clamp masses of treated asbestos or excelsior around the joints of ordinary land tile, which would prove effective. Such clamps could be constructed from heavy galvanized wire, so as to hold the excelsior very firmly around the joint, and at the same time not affect materially the inflow of drainage water. It would be possible, also, to make use of small sections of tile of larger diameter (collars), which could be placed over each joint and the treated fibers packed in tightly around the joints.

Creosote appears to be the best substance with which we have experimented, since it is not only one of the best preservatives, but possesses excellent toxic properties. No doubt there are other fibers than those which we have used, and there are many substances which possess properties toxic to roots, such as tannin, etc.; but many others, like sodium arsenate, wash out quickly and lose their effectiveness in a short time.

From the results of these experiments it would appear that chemically treated fibers would undoubtedly remain for many

years in the soil without serious deterioration, and if this treatment would succeed in doubling or trebling the usefulness of drain tile, it would be well worth while to employ it.

There is also the possibility of killing roots in tile by treatment with chemicals or gases, but little or no attention has been given to this phase of the subject.

Further experiments are being made along this line, and in the mean time it is hoped that more extensive and practical tests can be arranged.

THE CLOGGING OF DRAIN TILE BY ROOTS.

BY G. E. STONE.

Quite frequently trouble is experienced from roots of various trees entering drain tile, sewers, etc., and this often causes much vexation, labor and expense. The Carolina poplar, which is often planted as a shade tree in cities, frequently becomes a nuisance in consequence of its peculiar habit of working its roots through the joints of tile used for sewerage, etc. It is a comparatively easy matter for roots to gain entrance into the uncemented joints of tile, and even when tile is cemented they often manage to crowd in and fill the tile with a mass of roots which eventually clog it and render it useless. Instances are known of roots penetrating even sewers constructed of brick and cement. The roots of other trees besides Carolina poplars are known to be offenders in this respect. Willows, elms, etc., are responsible for considerable clogging of tile drains. There are also many instances even of fungi and algæ clogging up small drains. The writer some years ago had called to his attention a case where *Oscillaria,* one of the blue-green algæ, was constantly clogging tile, much to the annoyance of the landowner. On the Massachusetts Agricultural College grounds they have experienced much trouble with roots of various kinds clogging sewer pipes, and the drain tiles located under the steam pipes leading from the central heating system to the various buildings have become clogged.

In the case of the sewer tile referred to the joints were cemented with Portland cement, nevertheless, the roots gained entrance here and there through some of the joints, and in a short time they developed so profusely as to clog the tile, with the result that it had to be dug up and repaired. The joints of the 6-inch Akron tile underlying the steam-heating pipes are not cemented, and are located 5 feet or more below the surface. In two or three years after the tiles were laid some of them had

become clogged with the roots of elm trees. This clogging prevented the water from flowing through the tile, and caused a dam, as it were, resulting in the water flowing back into the conduit and flooding the steam pipes. A stream of cold water flooding steam pipes is not conducive to the best results, since it causes condensation and a decrease in the temperature of the steam. It is necessary, of course, to leave the joints of Akron tile open when used for the purpose of draining the conduit trench of a central heating and distributing plant, since these pipes must take off the water from the trench and prevent it from coming into contact with the steam pipes in the conduit. As long as the joints remain open it is with great difficulty that the roots of trees, etc., are kept from growing in the tile, and sooner or later it is made ineffective. Tree roots will penetrate tile protected with carefully cemented joints, and become a nuisance, as is shown by the following letter. In the city of Newark, N. J., the Shade Tree Commission has been requested by the department of sewers and drainage to omit the planting of Carolina poplars on streets since the roots of these trees proved to be a nuisance to drains, and the Shade Tree Commission has decided to plant trees which are less of a nuisance in this respect on the streets of Newark in the future. At my request Mr. Carl B. Bannwart, secretary of the Shade Tree Commission, Newark, secured this statement from Edward S. Rankin, engineer of sewers and drainage of the city of Newark: —

Replying to your letter of the 20th inst., we find that the roots go through the joints of tile pipe even when carefully cemented, and the trouble seems to be increasing. In 1909 we had 15 stoppages caused by roots; for the first eleven months of 1910, 23, of which 5 occurred in the month of November. These stoppages were all in house connections, and in addition to these we have also had a number of cases in our main pipe sewers. The roots after penetrating the pipe seem to spread out and practically fill the whole pipe. I have no way of knowing how long a time it takes for these roots to grow. To the best of my knowledge we have had no trouble with any of our brick sewers. The trouble seems to have been caused in all cases by poplar trees.

There recently came to our attention, through Mr. C. N. Minott, field superintendent on the gypsy and brown-tail moth work, a notable case where the small root from a pear tree had

gained entrance to a drain tile. This tile was 12 inches in diameter, and was laid about seven years ago to take the seepage waters from a reservoir located in the town of Belmont, Mass. This pipe passed through land owned by the Hittinger Brothers of Belmont, well-known and extensive market gardeners, and part of it passed near a pear orchard. There was a constant flow of water through this tile summer and winter, but the pipe was never full. At the time the tile was laid the joints were not cemented, and of course there was an excellent opportunity for roots of various kinds, if so disposed, to penetrate the joints of the pipes and secure an abundant supply of water. During November, 1909, about seven years after the drain pipes were installed, it became necessary to dig up a large part of them on account of their inefficiency and replace them. It was found on digging up this tile that it was badly congested by profuse root growth. A careful examination of the location showed that this growth of roots originated from a single off-shoot of a pear tree located some 7 feet away. This enormous mass of pear roots was removed from the tile and carefully laid aside, and we gladly accepted Mr. Minott's offer to present this to our museum. Mr. Minott later packed and shipped this to us, at the same time furnishing us full data concerning it. This mass of roots was found to measure 61 feet in length. Only a single root entered the tile, it having a diameter of about ½ or ⅝ of an inch. This root, when it entered the tile, immediately subdivided into innumerable rootlets, and these were again divided into countless smaller roots. At the time the tile was dug up and the roots removed the drain had been in operation seven years, although a cross-section of the root, together with an examination of the annular rings, where it entered the tile, showed that it was only five years old. Therefore it took only five years for this mass of roots to clog up a 12-inch tile.

The maximum diameter of these roots in the dry state is 6 or 7 inches, but when alive and flourishing in the tile their diameter exceeded this. The roots as they reached the laboratory had a decidedly bad odor, showing that if no sewage were present in the tile there was certainly a considerable amount of organic matter in the seepage, derived from the soil or some other source, which proved of value as plant food. Soon after the

specimens arrived at this laboratory they were spread out on the floor and measured. This was done by Mr. R. D. Whitmarsh, and was accomplished by laying out on the floor sections 5 feet in length. The number of roots in each 5-foot section was counted. This was multiplied by the length of the section and the whole tabulated (see table). The mass of roots was just 61 feet long, and the total length is 8,498 feet, equal to 1.61 miles in length. Adding to this the numerous small roots, which range from a few to several inches in length, and which were disregarded in our section count, the total length was estimated to be over 2 miles. This enormous development from a single root of a pear tree located 7 feet away is greatly in excess of what would take place if the roots were in the soil, since the conditions of the drain tile stimulate root development very materially. However, the root system of any tree or shrub is far in excess in length and area of what the layman imagines. The profuse growth of roots in water is also seen in cases where old wells become filled with root growth, but the pear tree root in question is one of the best examples which has ever come to our notice of root development in drain tile.

Table showing the Growth of Pear Tree Roots in Drain Tile.

Number of Section.	Length of Section (Feet).	Number of Roots in Section.	Length of Roots in Section (Feet).
1,	5	34	170
2,	5	41	205
3,	5	73	365
4,	5	153	765
5,	5	199	995
6,	5	313	1,565
7,	5	373	1,865
8,	5	447	2,235
9,	5	141	705
10,	5	53	265
11,	5	31	155
12,	5	36	180
13,	1	28	28
Total,	61	–	8,498

THE SPRAYING OF TREES.

BY G. E. STONE.

The great value and economic importance of spraying shade and fruit trees have resulted in placing on the market a large variety of fungicides and insecticides and types of machinery. Massachusetts has unfortunately been obliged to spend more money in spraying than any other State, and many towns and cities in the eastern part of the State, where the brown-tail and gypsy moths are so prevalent, spend thousands of dollars yearly in spraying.

Besides the larger spraying enterprises which are being carried on under the supervision of the Gypsy and Brown-tail Moth Commission, much private work is being done, and hundreds of tons of arsenate of lead are used annually in this work. While the above-named pests have not at present invaded the center and western part of the State to any extent, the presence of other pests necessitates spraying our shade trees.

The question of economical spraying on a large scale is an important one, and for a long time there has been a need for more efficient and cheaper methods. The writer, who has for many years had experience as tree warden, has had unusual opportunities to observe the work being done along this line in Massachusetts, and has felt the great necessity for improvements in the methods of spraying. It has often been a question whether our towns and cities can afford to use the methods which are recommended and practiced by the best orchardists for shade trees. The aim of the orchardists is to cover every part of the tree which needs protection with a very fine mist spray. This method cannot be too closely followed by orchardists, since it is not necessarily expensive when only orchard trees and small fruits and crops such as potatoes are concerned. When how-

ever, we have to spray large elms, the question is an entirely different one.

A few years ago some large elms located in the public square in one of our cities were sprayed by the same methods used by the best orchardists, at an expense of something like $16 per tree. These trees, to be sure, were unusually large, but the cost was so great that in our opinion it set a limit to the amount of spraying which should be undertaken by such methods. Most of the former spraying of shade trees was done by this very expensive method at a cost of $1.50 upwards for trees 14 to 18 inches in diameter. In much of this early spraying the Vermorel, Ware or similar fine spray nozzles on poles were used, and spraying had to be done at close range for the best results. The early gypsy moth work was done in this same way, any other method at that time being considered useless. This method entailed a great deal of climbing on the part of the sprayers, and was a slow and costly process.

Some years ago the Gypsy Moth Commission abandoned these fine nozzles and close-range methods of spraying, and now employs large nozzles and large hose, and exceptionally high pressure is obtained from powerful machine sprayers. With the larger area which has to be treated at the present day the older method would not only prove prohibitory on account of the expense, but also because of the time involved. Practically all the spraying with these large modern machines is done from the ground, doing away with the necessity for ladders and for climbing trees; and by the use of one or more long lengths of hose large areas can be treated from one spot. This method of spraying trees is very effective and very much cheaper, the average cost of spraying woodlands being something like $12 or less per acre. With this method the spraying mixture is delivered to the nozzle through a large strong hose under a pressure of 200 to 250 pounds, the high pressure breaking the spray up into a fine mist. The spray has considerable spread when broken up, which is a desirable feature in treating woodlands and country roadsides, but on this account it is more or less objectionable for use on residential streets in cities and towns, as it is likely to dis-

figure anything it touches. The writer has been of the opinion, however, for some time, that the high-pressure, large-nozzle equipments are the cheapest and most practical for shade-tree work.

What might be termed a compromise between the fine-nozzle system and the high-pressure, coarse-nozzle system employed in the gypsy moth work is often used in spraying shade trees at the present day. This consists in the use of the Bordeaux nozzle, which has an aperture of $\frac{3}{32}$ of an inch. When used on a hand pump with a pressure of from 50 to 70 pounds, or even more, it does not give, in our estimation, a satisfactory spray. Where a small number of trees are to be sprayed, and where an expensive equipment cannot be afforded, small hand pumps will do the work, but when it becomes necessary to spray 500 or 1,000 trees in the course of a few weeks, power sprayers are necessary and more economical.

The most important factors necessary for economical work in spraying shade trees on a large scale are machines powerful enough to maintain a constantly high pressure; an efficient nozzle, and competent men to do the work. By high pressure we mean a pressure of 200 to 250 pounds, preferably the latter. This should be maintained constantly, and the capacity should be sufficient to maintain this pressure in a 1-inch delivery hose, if necessary.

In our work on spraying shade trees we endeavor to have a 1-inch aperture from the pump to the nozzle, care being taken to have no reducing valves or couplings anywhere on the line to reduce the volume of the spray, since it is better to have a good flow of the spraying mixture directly to the nozzle.

Too much attention cannot be given to the nozzle. It should be adapted to the work required of it, and a satisfactory nozzle is worth almost any price. It should be constructed on mechanical principles which will enable it to break up the spraying mixture into as fine a mist as possible, and to do this at a distance convenient for the economical application of the spray. The ideal nozzle for the economical spraying of trees either from the ground or a ladder should possess some carrying fea-

tures, and still break the spray up finely. The nozzle should not be encumbered, any more than the hose, with worthless mechanical devices which produce friction without adding anything to its efficiency, and for this reason we believe that it is better to employ mechanical devices to break up the spray after it has left the nozzle rather than in the nozzle itself. This applies, of course, to that type of nozzle intended to be used with high pressure, either from the ground or from a ladder, since in this case it is necessary for us to have nozzles adapted to throw a certain distance in order to reach the foliage, and have it broken up into as fine a mist as possible. This does not apply to types of nozzles like the Vermorel and Friend, which are well adapted to the purposes for which they are intended.

The question of competent men and good machinery is also important in spraying. Any good reliable man of common sense can learn to spray in a short time, and there should be little difficulty in securing such men if they are treated properly and well paid.

As regards spraying outfits, there is still a chance for improvement in many ways. There are, however, many good power sprayers on the market. The New Leader spraying machine, made by the Field Force Pump Company of Elmira, N. Y., of which there are several in use in the Connecticut valley, has proved to be satisfactory. This is provided with a 3½ horsepower engine, and is one of the cheapest and best machines on the market. A machine of this type, while not so thoroughly constructed in some respects as the larger and more expensive machines, is capable of doing good work for some years. The type of machines which depend upon charging with carbonic acid gas for their power we consider failures for any kind of work, since the pressure is never constant, and much of the time is too low for any kind of spraying. The company which manufactures these has recently constructed a machine in which the power is compressed air instead of gas. This air is constantly pumped and pressed into large cylinders, which are attached to the truck. One of the difficulties in a machine of this type for high-pressure work consists in the use of very heavy

cylinders, which, on account of the weight, must have a limited capacity for storing the air. There are on the market many good hand pumps which will maintain a pressure of 50 to 70 pounds with an ordinary nozzle, and these may be purchased for $12 to $20. For general purposes they are the cheapest and most satisfactory spraying devices produced at the present time.

SHADE TREE TROUBLES.

BY G. E. STONE.

If the amount of correspondence is any criterion of what people are interested in it might be inferred that the citizens of Massachusetts place a high value on shade trees, and we are receiving an ever-increasing number of such inquiries. Such organizations as civic leagues, village improvement associations, the Massachusetts Forestry Association and the different horticultural societies are very largely responsible for this awakened interest in the subject of shade trees, although landscape gardeners and highway and park commissions have had no small influence in this direction.

Shade trees have enough to contend with ordinarily, but the extreme climatic conditions which have prevailed during the past few years have been an additional burden on them. The more extensive use of telephones, electric lights, trolley transportation, gas, sewers, aqueduct water, etc., made necessary by modern conditions, has been hard for our shade trees, and the severe winterkilling of roots, which occurred a few years ago, has been responsible for the death of thousands. Many trees which were not so seriously injured a few years ago as to die outright were left to a lingering existence, and many of them are constantly deteriorating and in a few years will be dead. The trees which have shown this slow dying back of the root system most prominently, and which later completely collapse, are the elm, red maple, black and white ash, and, to a less extent, the rock maple. The writer has had opportunity to observe the condition of a large number of these trees each year and the effect which root killing has had upon them. Many large elms, which a few years ago were in perfect condition, may be seen slowly dying from the effects of severe climatic conditions, and

many of them gave promise of living at least one hundred years in favorable environments. The black and white oak, ash and red maple are dying more rapidly than the elm. The European birch, so commonly used for ornamental purposes, has been dying everywhere this past summer from the effects of borers. and possibly the extreme drought.

The past summer the writer has had an opportunity to examine many black oaks along country roadsides, where the conditions for tree growth would be considered fairly good. These trees are located in different towns in the eastern part of the State, where the oak seems to be affected the most severely. Near one estate, where 19 black oaks (*Quercus velutina,* Lam.) were examined, the larger part of them were found to show evidence of root killing. These trees are located on a slight embankment, and that part of the root system nearest the road was invariably affected the worst. The trees showed various degrees of root killing, some of it being so far advanced that 75 per cent. or more of the tissues of the trunk were dead on the roadside. Some of the trees were in fairly good foliage, others had lost a little foliage, and many had considerable dead wood, the amount corresponding to the condition of the roots. On another roadside, where the conditions were somewhat similar, although in a different town, the same root killing was observed. In this locality there were 50 or more black oaks, many with scarcely any live limbs, and supporting only from 1 to 20 per cent. of the original foliage. An examination of these trees showed the trunks to be perfectly sound, and even the larger roots at the base of the tree were alive. When the soil was removed from the roots for a distance of 3 or 4 feet it was found, however, that practically the whole root system had collapsed, and conditions showed that there had been a slow but constant dying back of the roots for the last five or six years. For example, roots 1/4 inch in diameter, which normally would extend 15 to 25 feet from the base of the tree, had died back to within 3 to 6 feet from the base. It could be plainly seen that the trees had made strenuous efforts to recover their root systems by repeatedly throwing out a profuse growth of side roots, but as the affected roots were continually dying back, the new laterals were of little or no use,

as they would die in turn. Had it been possible to prune these roots, their dying back could have been checked, a new system of secondary roots would have formed and the tree would have recovered. Oak trees in this condition have been fairly common in certain parts of eastern Massachusetts for the past few years, and many more will show the same symptoms later.

Another trouble which has been more or less common the last few years is known as sun scald of maples. This is responsible for injuring many valuable shade trees. On one avenue we recently observed 16 rock maples killed by sun scald. This affects the trunks and limbs on the side of the tree exposed to the sun. It is characterized by a drying up of the bark, which almost immediately becomes affected with a canker fungus (*Nectria cinnabarina,* Fr.). On smaller trees sun scald often kills the whole trunk. Generally only one side of the tree is affected, and occasionally one or more branches. The root system is not affected by sun scald, and limbs are much less likely to be affected than the trunk. The fact that the root system is not affected by sun scald, and that the bark usually becomes infected with *Nectria,* makes it easy to distinguish this type of injury from that caused by gas poisoning, since in this case the *Nectria* never appears, but, instead, profuse growths of *Schizophyllum* and *Polysticta* are present. Very similar effects are produced on the trunk when the tree is sprayed with kerosene or crude oils, since *Nectria* almost always accompanies such injury.

Sun scorch differs from sun scald very materially, as it affects only the foliage. This is very common on maples, and in recent years the white pine has been affected in this State. Sun scorch follows dry periods, and is usually associated with strong, drying winds, lack of water in the soil, etc.; in fact, it may be caused by various abnormal functions of the root system. It hardly ever completely defoliates trees, and on maples it simply burns the foliage, particularly on the windward side. Various conifers, such as arbor vitæs, when grown in dry soil invariably show sun scorch in the spring, particularly when there are drying winds and the ground is frozen. For many years past we have received a large number of inquiries concerning the effects of sun scorch on maples. These effects resemble those of leaf

blight (*Glœosporium*), and various atmospheric gases, or illuminating gas, escaping into the soil, often cause effects resembling those produced by sun scorch. Severe injury is caused especially by the illuminating gas. Under ordinary conditions trees seldom recover when once poisoned by this gas. It is possible, however, in certain cases of gas poisoning, especially in the incipient stage, to amputate certain roots at the base of the trunk, which prevents the further translocation of the poisonous substances and often saves the tree.

Every tree which dies along the roadside, however, is not necessarily killed by gas or electricity, notwithstanding the fact that this seems to be a popular belief. It should be said that the public service corporations of Massachusetts, on the whole, take a very sensible and unbiased view of the claims for gas injury, and if the people would meet them in this same spirit adjustments of legitimate claims for damages would no doubt be satisfactorily made in practically every case.

THE CHESTNUT DISEASE (DIAPORTHE PARASITICA).

BY G. E. STONE.

The chestnut disease, which has wrought such destruction in the vicinity of New York since 1904, has been observed quite extensively in some parts of our State the past summer (1910). Occasional reports of the disease occurring here and there have been received for three or four years, but such reports, when investigated, proved to be groundless. Whenever a chestnut tree in a more or less unhealthy condition has been observed, the cause of the trouble has promptly been put down as chestnut disease. It is possible that the chestnut disease has been present in Massachusetts for three or four years, but it has not been called to our attention, neither has any systematic attempt been made on our part to locate it.

It has been reported by J. F. Collins in Rhode Island, and he has traced it over the Rhode Island line into Massachusetts. The territory which appears to be most severely affected in this State is the Connecticut valley, where the disease may be seen over quite an extensive area. Mr. Sumner C. Brooks went over a considerable territory this past summer and reported several hundred trees affected. Some of them appear to have been dying for three or four years, according to the best information we are able to obtain, and some of the injury may date back even further than that. The disease exists, no doubt, in other parts of the State, although little has been found at the present time. From a more or less hasty survey of the State, made by this department last summer and fall, together with correspondence and inquiries, we were able to discover little, if any, of the disease outside of the Connecticut valley region. As in the case

of the elm-leaf beetle and other pests, the disease seemed to be more common at first in the Connecticut valley.

The writer has been informed by one who has had some opportunity to observe this disease that it appears to be less prevalent on high elevations than in the valleys. This opinion is, of course, based on merely casual observations. Whether there is really any distinct difference between valleys and high elevations as regards the prevalence of this disease would be interesting to observe. If this were the case, one might expect to find the disease most commonly in the valleys, like the Connecticut, Blackstone, Housatonic, etc., in this State. It is, however, quite significant that the Connecticut valley region should possess such a large amount of infection as compared with other sections. We have noticed for some time that there is a difference in the degree of winterkilling occurring in valleys and high elevations in this State. By far a greater amount of winterkilling of trees occurred in river valleys and on the lower elevations during the severe winter of 1903–04 than on the higher elevations, the Connecticut valley being especially notable in this respect. It is, moreover, a significant coincidence that the chestnut disease should make its appearance at about the same time that vegetation was so severely injured by the severe cold which occurred during the winter of 1903–04 all over the northeastern part of the United States.

Our observations on the effects of meteorological conditions on vegetation, and the unusual opportunities we have had to study shade-tree conditions for some years, have brought to our attention the unusually large amount of dead wood found on chestnut trees the past four or five years., From what we have seen of the chestnut during this period we are of the opinion that it has not been in the best condition during late years, and that the chestnut, like the native white and black oaks, elm, red and rock maples, ash, etc., has been more or less affected by the severe cold and drought of late years. It is intended during the coming year that a more serious and thorough investigation of the cause and distribution of the chestnut disease be made in this State. In the meanwhile it is essential that lumbermen cut off their diseased trees and make use of them now.

CROWN GALL.

BY G. E. STONE.

For many years a disease known as crown gall has affected raspberries in this State. The disease is characterized by large abnormal swellings or gall formations near the crown of the roots, and is well known to all raspberry growers. Raspberry plantations are almost invariably affected with crown gall after being set out for a few years, and in the course of time these galls affect the plant to such an extent that the crop is no longer profitable, and it becomes necessary to start a new plantation. In recent years other plants have become affected with crown gall, which is becoming more common on the roots of our fruit trees, notably the apple, pear and peach, although until five or six years ago galls on fruit trees were very rare in Massachusetts; at least, if they existed at all they were limited to certain areas, and were brought into the State on infected nursery stock.

It is quite certain that the germs of crown gall are not indigenous to our soil, and in all cases the disease has been introduced through nursery stock from outside the State. Apple trees have been grown in the State for years without being affected, and it is reasonable to suppose that they may be grown to-day in most of our soil without infection, providing clean stock is secured when planting an orchard. However, when crown gall is once introduced into an orchard it is difficult to prevent even clean stock from becoming infected. The writer knows of a large tract of land, which was, until three years ago, free from crown gall, where to-day it is impossible to plant even seedlings without their becoming infected. The soil in this instance was first infected by imported stock; and undoubtedly by the use of cultivators, etc., the disease germs have been spread over a large part of the cultivated area. The organism causing

the galls is, according to Smith and Townsend,[1] a species of bacillus; and, if true, this would explain the readiness with which the disease spreads and infects heretofore uninfected areas. It appears to be doubtful, however, whether the organism causing crown gall of the raspberry is identical with that causing the galls on the apple, at least in this territory, since raspberries have been affected for many years in this State, and fruit trees only recently; moreover, raspberries have been grown for years in close proximity to fruit trees in all stages of development without the slightest evidence of gall infection.

Unusual interest is now being shown in fruit growing in this State, and the appearance of a disease of this nature must be given consideration. Considerable difference of opinion exists in regard to the effect crown gall may have upon a tree, and there is still much to be learned in regard to the seriousness of this trouble. Some authorities claim that crown gall does no harm whatsoever, while others give alarming accounts of the serious damage it causes. It would appear, however, that crown gall is less to be dreaded in New England than in some other sections of the United States. This is the opinion of F. C. Stewart of the Geneva Agricultural Experiment Station, Geneva, N. Y., who has had unusual opportunities to observe crown gall in the New York orchards and nurseries. The most intelligent orchardists, however, prefer stock free from the disease, and most of them refuse to accept contaminated stock from a nursery firm. A very large amount of infected nursery stock has, however, undoubtedly been shipped into this State and planted without the buyer knowing that it was affected.

We have had many opportunities recently to observe crown gall on apple, pear and peach trees, and in some cases on the Carolina poplar, but we have seen only one or two instances where trees have been so badly affected that they have died from the effects of the disease. Much affected stock has been thrown away and burned, not being considered suitable to place on the market. Crown gall on fruit tree stock has become so general in nurseries at the present time that one large concern has found it practically impossible to obtain stock free from it, and this

[1] E. F. Smith and C. O. Townsend, Science, n. s., Vol. 25, April, 1907, pp. 671-673, also Vol. 30, No. 763, Aug. 13, 1909, p. 223.

firm is in a quandary as to what to do. When one has a young orchard with 50 per cent. or more of the trees affected, the question arises as to what should be done with it. It is possible, also, that one might obtain stock from a nursery free from galls, yet the soil from which they were taken may have been contaminated, and in this way the disease might break out later, when the stock was transplanted. Even though it is not certain that crown gall on fruit trees is of serious consequence, affected trees are certainly not in a normal condition, and the functions of the tree must be more or less interfered with, since the conductive tissues in the galls are to a greater or less extent misplaced and contorted, according to the severity of infection. There is, moreover, a risk in planting trees affected with gall, since one can never know when some complicated trouble may arise, owing to the presence of such malformed tissue.

There is a great deal known in regard to the effects of galls on plants in general, and it is known that they cause much injury.

The writer has devoted many years to the study of galls caused by eel worms (*Heterodera*). Some plants affected with eel-worm galls present few abnormal features as regards vigor and yield, while others become sickly, and many die outright.

Tomatoes grown under glass are often affected quite severely with galls caused by eel worms. These very rarely, if ever, kill the plant, and in the great majority of cases, so far as we have observed, do not affect them severely. On the other hand, cucumbers appear to be often seriously affected, and while many plants will live when the roots are covered with galls, others will die, and the yield is, in practically all cases, materially reduced. Muskmelon plants are even more severely affected with eel-worm galls than cucumbers; to such an extent, in fact, that it is seldom that an affected plant is not killed before reaching two or three feet in length. The roots of roses are also susceptible to eel worms, which form almost microscopic galls, and often reduce the productiveness of this crop 75 per cent. A considerable loss of money has been experienced by rose growers from this cause. This is also true of violets. According to our own experiments

the yield of violets is greatly affected by these galls, and the plants often die outright.

In conclusion it might be said that the effects of crown gall on fruit trees may have been often exaggerated. There is a probability of some young nursery stock affected with crown gall developing into good trees, but clean stock should be obtained from localities free from the gall, if possible. Many States have laws for the purpose of excluding crown gall stock, but this disease has become so common, and certain varieties of nursery stock so scarce, that it is a question whether at the present time Massachusetts nurserymen would be able to supply the demand for clean material for contemplated orchards if a prohibitory law were passed.

FUSARIUM DISEASE OF CUCUMBERS AND OTHER PLANTS.

BY G. E. STONE.

A type of disease caused by one or more species of *Fusarium* occurring on different plants gives rise to what are known as wilts, stem rots, etc. *Fusarium* troubles have become more common of late years, and many houses which have been entirely free from them in the past now seem to become affected sooner or later. The dry stem rot of the carnation, caused by *Fusarium,* was unknown to florists years ago, but for ten years or more it has been one of the most common and dreaded pests known to carnation growers. *Fusarium* stem troubles have been observed occasionally on greenhouse tomatoes for the past few years, but fortunately no great amount of damage has so far resulted from this disease. Asters, chrysanthemums, potatoes, etc., are affected with *Fusarium* stem rots, and in the case of the aster the disease is often quite common and destructive.

Fusarium troubles of a minor and insignificant character have in previous years been found on greenhouse cucumbers, and within the last year a few serious cases of infection have been brought to our attention. All these cases were confined to greenhouses, and were severe enough in some instances to entirely ruin the crop. The material sent in to the laboratory showed both roots and stems affected with the fungus.

The summer crop of muskmelons, grown in the department's conservatory, was also affected badly, the disease appearing first on a few plants, but eventually spreading over practically the whole house. It was first characterized by a wilting of the leaves, which was more noticeable in warm, sunshiny weather. At first there is a tendency for the leaves to recover in the night

after wilting occurs, but as the disease becomes more severe the plants wilt more badly, and after a time die. Examination of the roots and stems near the surface of the ground showed evidence of the fungus *Fusarium.* In some instances this fungus has been traced quite largely to the roots and stems. The fungus develops principally in the wood ducts, eventually clogging them by shutting off the water supply from the roots.

As the disease has been called to our attention only recently we have not had an opportunity to study it thoroughly or to give the matter of remedies much consideration. It may be found, however, that, like many others, it will prove to be merely sporadic, and little may be heard from it in the future; although on the other hand, it may become a permanent and serious trouble.

Cucumber crops are unusually susceptible to certain troubles which in many cases are traceable directly to mismanagement. Practically all cucumber growers force their plants to the limit, regardless of external weather conditions, in this respect differing from florists and other market gardeners, who endeavor to adapt their crops to weather conditions. Too much forcing in the fall months, when the sunlight is poor, produces a tender tissue peculiarly susceptible to disease, and is a bad practice. There is no doubt, in the writer's estimation, that crowding the plants and extensive forcing, especially when the sunlight is poor, are responsible for a large part of the modern *Fusarium* troubles. Some years ago we found in our experiments that young aster plants which had been forced under glass in sterilized soil were decidedly more susceptible to stem rot than those grown in ordinary soil out of doors. The sterilized plants grew so rapidly that the tissue was very tender; whereas those grown out of doors formed tissue of an entirely different texture, which was less susceptible to disease. The stems of cucumber plants are often in bad condition near the surface of the ground, due to a combination of circumstances. Mites, eel worms, bacteria, etc., often affect the stem at this point, causing lesions and serious disruption of the tissue, and stems in this condition easily become affected with one trouble or another. The *Fusarium*

trouble at present appears to be merely incidental, attacking the weakened stems at the surface of the ground; but further observations on this point are necessary.

Sunlight constitutes the best factor for hardening up tissue, and the degree of resistance of the stems to disease coincides with the amount of light they receive. Besides sunlight, plenty of air is needed for the hardening of tissue, and if more attention were given by cucumber growers to adapting their plants to external conditions, healthier and stockier plants would be produced. On cloudy days the night and day temperatures should be lower than on bright, sunshiny days, and in this way the new tissue, as well as the old, becomes hardened, and is less susceptible to attacks from various organisms.

Lettuce growers are always very careful to lower the day temperatures in cloudy weather, whereas in periods of sunshine higher temperatures are maintained. They force their plants, to be sure, but use the greatest judgment in doing it, whereas cucumber growers, as a rule, pay little or no attention to outside conditions.

Experiments are now under way for the further study of this trouble, and various treatments will be tried.

There have recently been reported from other States serious troubles affecting outdoor crops of melons and cucumbers, characterized by wilting and dying of the plants. Serious loss was reported in Rhode Island the past summer resulting from some blight. F. L. Stewart has described a serious blight of melons occurring in New York State,[1] and L. R. Jones has described a bacterial blight in Vermont.[2] Both of these blights are different from the one described above.

Our attention has often been called to the cracking or splitting of melons in the fall. This occurs on mature, ripe melons, and in our opinion it is caused by the absorption of water by the fruit. When melons are lying on the ground the water sometimes gains entrance to the blossom end of the fruit, causing an increased turgescence of the inner tissues which exerts such a pressure on the fruit that it cracks. We have been able to pro-

[1] Geneva, N. Y., Agricultural Experiment Station, Technical Bulletin No. 9, 1909.
[2] Vermont Agricultural Experiment Station, Bulletin No. 148, 1910.

duce this cracking of the fruit by placing the blossom ends in saucers of water. Sliced melons, when placed in a dish of water, will straighten out noticeably, from the excessive absorption of water by the inner cells. On the other hand, when sliced melons are placed in normal salt solutions of certain strengths the melon will contract or curl up.

CONDITION OF FRUIT TREES IN GENERAL.

BY G. E. STONE.

Any one who has been acquainted for any length of time with the fruit industry of this State must have noticed its condition the past few years. Massachusetts has never been noted as an extensive fruit-growing State, and very few large orchard enterprises have ever been developed. There have also been comparatively few orchards which have been kept in first-class condition; in fact, the condition of fruit trees has never been so bad in the history of the Commonwealth as during the past four or five years. The severe and erratic climatic conditions to which our fruit trees, in particular, have been subject, together with the San José scale, have been the means of killing thousands of our fruit trees, and greatly lessening their productiveness and the quality of the fruit. All this, combined with wholesale neglect, has placed the fruit industry at a very low level, and it is not at all surprising that apples bring at times a very low price. The severe winter of 1903–04 was not confined to our State, as its work may be seen throughout the whole north-eastern section of the United States, and in many instances large orchards were wiped out entirely.

From observations made in other States it would appear that our trees do not suffer so severely as in some other places, but the fruit has been of exceptionally poor quality. A large part of the injury to apple trees was confined to the roots, although a large amount of sun scald, which was subsequently associated with canker, was noticeable on the branches. Good systematic pruning, feeding and cultivation would have remedied much of this injury, but until the past year or so, when there has been a renewed interest in orcharding, no attempt has been made to renovate these neglected orchards. The remarkable price which

western apples bring in our markets has stimulated Massachusetts orchardists to make use of better scientific methods in fruit growing, and it is no exaggeration to state that there have been more pruning, spraying, cultivating and fertilizing apple orchards in the past year in this State than for thirty years before. This increased interest is being shown by professional orchardists as well as by smaller growers, and the quality and yield of fruit the past season is ample proof of the great value of this treatment. It is, however, a significant fact that the few first-class apple orchards which are to be seen here and there have not experienced the same setback, either from scale or winterkilling, that the neglected trees have, and some orchards have been producing good fruit each year, although the severe drought which we have experienced the last two or three years has affected trees somewhat.

Peach orchards have suffered severely of late years from root killing and other troubles, and some of the orchards which were in excellent condition a few years ago are looking badly now. Some growers attribute this deterioration to peach "yellows." A large part of what is supposed to be "yellows" is not this at all, and the yellow foliage and general unhealthy condition which have been common the past few years are nothing more or less than the effects of unfavorable climatic conditions. Pear, quince and cherry trees have likewise suffered from scale and winter injury in the same way that apple trees have. The pear, moreover, has been affected severely by aphis and surface molds. This could have been remedied by spraying with whale oil soap or kerosene emulsion. The quince has been rather badly affected by rust. Practically all the old cherry trees have suffered serious injury, and, as few new trees have been set out, cherries are becoming scarce. The small fruits, such as the raspberry, blackberry and strawberry, owe much of their present condition to unfavorable climatic conditions, and the cane blight, which has recently affected raspberries, etc., may be merely a secondary effect of some other cause.

It is, however, necessary that the work of spraying fruit trees be continued, since the results obtained fully justify the extra expense involved. The treatment necessary for fruit trees in

general may be summarized as follows: if scale is present, spray in the fall with some reliable oil. In the early spring spray again with lime and sulfur, before the leaves appear. About the time the petals fall, spray again with arsenate of lead, for codling moth. Ordinarily this spraying is sufficient, but if any fungous troubles appear, a later spraying with Bordeaux mixture, or with dilute or self-boiled lime sulfur, would be valuable. These various treatments are recommended for both fungi and insects, and although the oil, and lime and sulfur treatment are especially applicable for scale, it has been found that the latter, particularly, has proved to be the most effective fungicide we have. Even one application of lime and sulfur in the spring has a remarkable effect as a fungicide throughout the whole season, and in our opinion it is more efficient than any number of sprayings with Bordeaux mixture for certain troubles common to fruit trees. Arsenate of lead is primarily for codling moth, but this, too, has fungicidal properties, according to the writer's observations. We believe that for orchards which are well pruned, cultivated and fertilized the three sprayings recommended above would be sufficient for any ordinary year, and in case the scale is not present, the oil treatment could be left out. The lime and sulfur, however, is worth applying every year, whether the scale is present or not, owing to its remarkable fungicidal properties. There are now on the market many kinds of oils and concentrated forms of lime and sulfur which can be used to advantage. It is a question, however, whether the concentrated forms are as effective as the home-made. Much attention is now being given to the self-boiled lime and sulfur, but it is somewhat too early to state definitely its value as a fungicide.

The apple industry is now booming in this State. Many young orchards are being set out; more attention is being given to pruning, spraying and cultivating, and within a few years there will be many more good orchards than at present.

A NEW TYPE OF SPRAY NOZZLE.

BY G. E. STONE.

For some years the writer has given considerable attention to the improvement of nozzles, and has experimented with various types. In a preceding article on the spraying of trees we have already referred to the importance of nozzles being adapted to specific cases, and from time to time we have sketched and had constructed in a simple way new types of nozzles, which have been tested. The principles involved in these nozzles were in many cases new, but when the nozzles were constructed and tried out, some of them, as might be expected, were more or less failures. Various methods and devices were used and tested to break up the spray, and in one case a rotary wheel of a turbine type was tried.

Without going into a detailed description of the various types of nozzles which we have worked upon we will confine our attention to one of these which has proved to be remarkably satisfactory in spraying large trees from a high-pressure machine. This nozzle is shown in Fig. 1, at *A*. It consists of a nozzle screwed tightly onto the tip of a standard attachment provided with shut-off, such as is often employed in spraying work (see *B*). The attachment, however, is incidental, as it may be fitted to any suitable metal connection threaded to fit, and provided with a hose connection at the lower end. The essential part of the nozzle, as shown at *A*, consists of a small brass tip, *t*, about 1½ inches long, provided with an aperture at the end ⅛ of an inch in diameter, although sometimes an aperture of 5/32 or 3/16 of an inch in diameter has been employed. About an inch or more above the center of the aperture there is placed a solid brass rod, *c*, ¼ of an inch in diameter. This is attached to another rod, *d*, by means of a thin sheet of brass; the rod, *d*, works in a socket, and allows the pointed brass rod, *A*, to be thrown in or

out of center at will. The object of this center brass rod, *c*, is to take the spray as it comes out of the ⅛-inch nozzle under high pressure and break it up into a fine mist, and with the pressure which we used it is capable of throwing the mist 20 or 25 feet. This is sufficient to reach, from a ladder, most of the foliage on a large elm tree. In case it is necessary to reach higher, the ad-

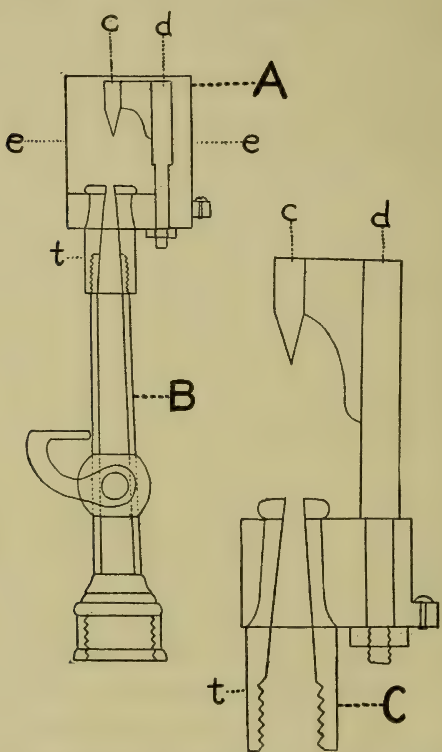

Fig. 1. — Showing a new type of spray nozzle adapted to high-pressure work on large trees. *A*, essential part of nozzle; *B*, ordinary attachment provided with shut-off; *C*, nozzle enlarged without a guard; *t*, small brass tip; *e*, guard; *c*, pointed brass rod to break the spray; *d*, rod to support the same.

justment is thrown out of the center and the spray goes directly through the ⅛-inch aperture. By this means a greater distance and carrying power are secured, although not so fine a spray.

This type of nozzle has proved to be very successful, and was used throughout the whole summer with the best results.

In the drawing the nozzle is shown surrounded by a shield, *e*, which was for the purpose of protecting the point, *c*. The nozzle as originally constructed was not provided with a shield, being used for some days without it, but with the hard usage which it received we found that the adjustment was likely to be injured. The nozzle was used in connection with a machine giving 250 pounds' pressure, and the spraying mixture was carried through a 1-inch hose.

This nozzle was used, the past summer, in spraying over 1,000 trees, having an average diameter of about 22 inches. Careful estimates made showed that the average amount of arsenate of lead per tree was 1.7 pounds, or about 17 gallons of arsenate of lead in solution. The cost of spraying each tree, including the labor, gasolene and lead, was 55 cents. A smaller number of the same trees were sprayed some years ago at a cost of $1.50 per tree; but the spraying with the new nozzle and machine was in every way as good, and the cost about two-thirds less per tree, as by the more costly method, which consisted in the use of the Vermorel and other fine-mist nozzles.

DISTILLERY AND BREWERY BY-PRODUCTS.

BY J. B. LINDSEY.

A. Distillers' Dried Grains.

(a) *What they are.*

Distillers' dried grains represent the residue from the manufacture of alcohol, spirit and whiskey from the several cereals. Briefly stated, the process of manufacture consists in treating the ground grains with a solution of malt at a temperature of about 145° F., in order to convert the starch into sugar. The barley and other cereals from which the malt is made, as well as the malt sprouts, are added as a part of the malt solution. After the changing of the starch into sugar, the entire mass is cooled to a temperature of 60° to 70° F., and yeast added, thus changing the sugar into alcohol, which is distilled. The residue or distillery slop is filtered, dried by steam in especially constructed driers, and put upon the market as a cattle food. It consists chiefly of the hulls, germ and other nonfermentable portions of the grains. It has more or less of a sour taste and smell, due to the fermentation. In order to be of satisfactory quality, the mash should be dried at once after the process of fermentation is completed. If allowed to stand too long it is more or less contaminated with acid and other injurious products of fungous and bacterial action. If heated too hot during the drying process it is scorched, which causes a disagreeable burnt taste and odor, and a lessened digestibility. A well-dried product should be of a light brown color and possess a pleasant odor. Experienced parties state that the quality of the dried grains depends, first, upon the quality of the distillers' mashes (upon the kinds and proportions of the grains employed); second, upon the distillers' mode of mashing; and third, upon the process of drying.

(b) *Classification of Distillers' Grains.*

The grains may be classified as follows, according to the source from which they are derived: —

1. Alcohol and spirit grains are produced by the alcohol and spirit distillers, located in Indiana, Illinois and Ohio; they are the most uniform in grade, corn being practically the only grain used. The yearly product is from 50,000 to 60,000 tons.

2. Bourbon whiskey grains, from the whiskey distilleries, located mostly in Kentucky, vary in composition according to the proportion of corn, rye and malt in their mashes. The larger the proportion of corn and the smaller that of rye and malt (small grain, so called), the higher the grade of dry grains produced. The distilleries producing these grains run about one hundred and fifty days between November and July, and turn out from 27,500 to 35,000 tons.

3. Rye whiskey grains, from the rye whiskey distilleries, located near Pittsburg, Pa., and Baltimore, Md., run during the winter and spring, and may produce approximately 7,500 tons.

(c) *Disposition of Distillers' Grains.*

Formerly practically all of the dried grains were exported. About ten years ago the home market was sought, and considerable quantities were sold unmixed with other feedstuffs. Of late the better grades have been largely utilized by home manufacturers of proprietary feeds. The rye grains have never been very popular in the United States, and the entire product is usually exported. The present season (winter of 1910–11) the foreign market is said to have been poor, and the material has been freely offered at $16 per ton in bags at wholesale, f. o. b., Boston points, which would be equivalent to substantially $1 per hundred at retail. Such a price renders this article quite economical for northern feeders.

(d) *Composition of Distillers' Grains.*

The following summary represents the average percentages of the ordinary food groups in the several varieties of grains: —

	Number of Samples.	Water.	Ash.	Protein	Fiber.	Extract Matter.	Fat.
Distillers' grains (alcohol and spirit),	81	8	1.7	31.7	12.3	34.1	12.2
Distillers' grains (whiskey), . .	1	7	2.5	26.2	11.5	43.0	9.8
Distillers' grains (rye), . . .	5	7	1.6	15.6	13.5	55.4	6.9

The alcohol grains are the only ones usually found in the Massachusetts markets. They contain 30 or more per cent. of protein and about 12 per cent. each of fiber and fat. The rye grains reach 15 to 16 per cent. of protein, and contain some 13 or more per cent. of fiber. Recent analyses show that substantially all of the crude protein in distillers' grains is present as true albuminoids.

(*e*) *Digestibility of Distillers' Grains* (*Per Cent.*)

	Alcohol and Whiskey (17 Trials, 8 Lots).	Gluten Feed for Comparison.	Rye Grains (2 Trials, 1 Lot).	Wheat Bran for Comparison.
Dry matter, ...	79	88	58	66
Protein, ...	73	85	59	77
Fiber, ...	95	87	50	39
Extract matter, ...	81	90	67	71
Fat, ...	95	81	84	63

The alcohol or corn grains show a somewhat lower digestibility than does the gluten feed, but are much more digestible than the rye grains. If the average percentage composition is multiplied by the above digestion coefficients, we have the percentage or pounds digestible in 100: —

	Alcohol Grains.	Gluten Feed.	Rye Grains.	Wheat Bran for Comparison.
Protein, ...	23.1	22.0	9.20	12.4
Fiber, ...	11.7	6.3	6.75	3.9
Extract matter, ...	27.6	48.0	37.12	37.8
Fat, ...	11.6	2.6	5.80	2.8
Total, ...	74.0	78.9	58.87	56.9

On the basis of the experiments and estimates made by Kellner, allowing for losses in the (*a*) fæces or undigested material, (*b*) incompletely used material or urine, (*c*) work required in the processes of digestion and assimilation, the following net energy values (expressed in therms [1]) are calculated in 100 pounds of the several feeds: alcohol grains, 80.2; gluten feed, 77.8; rye grains, 54.9; wheat bran, 49. It will thus be seen that the alcohol distillers' grains and gluten feed approach each other quite closely in feeding value, and likewise the rye grains and wheat bran.

A carefully conducted feeding trial with 6 cows,[2] in which a good quality of alcohol distillers' grains was compared with gluten feed, led to the following conclusions: —

1. The experiment has shown the distillers' grains to be fully equal, if not rather superior, to standard gluten feed in their nutritive value, and without objectionable effect on the health of the animal.

2. Their bulky nature enhances their value as a grain feed for most kinds of farm stock.

3. The flavor and keeping quality of the milk appeared in no way to be affected when this food constituted one-half of the daily grain ration.

It must be understood that grains that have undergone serious fermentation before drying cannot be considered as a first-class food, and their use is not recommended for either dairy animals or for horses.

(*f*) *How to use the Grains.*

For Horses. — Plumb,[3] as a result of feeding distillers' grains to horses, found that some of the animals did not relish the product. The Massachusetts Agricultural College has fed its farm horses, with excellent results, a ration containing one-fourth distillers' grains; Pott [4] reports favorably on the use of 6½ pounds distillers' grains in place of 8 pounds oats; also

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[1] The therm represents the amount of heat required to raise 1,000 kilograms of water 1° C. It is to be preferred to the small or large calorie as a unit of measurement, because it can be expressed in fewer figures.

[2] Bulletin 94, Hatch Experiment Station, pp. 6–10.

[3] Bulletin 97, Indiana Experiment Station.

[4] Handbuch der tier. Ernährung, etc., von Pott, III Band, p. 293.

2¼ pounds distillers' grains, 2¼ pounds brewers' grains and 9 pounds corn in place of 9 pounds oats and 9 pounds corn.

For Fattening Cattle. — May [1] reports quite satisfactory results in feeding by weight one-half distillers' grains and one-half corn and cob meal to fattening cattle. It is believed that such a proportion is a desirable one, and that the distillers' grains can be thus utilized to good advantage.

For Pigs. — The distillers' dried grains are less desirable as a food for pigs, owing, partially at least, to the considerable amount of fiber present. They could probably be fed to better advantage in their natural state, *i.e.,* in the form of distillery slop.

For Dairy Animals. — The distillers' grains have been found to be exceedingly well suited to milk production. A few rations are suggested: —

I.

100 pounds distillers' grains.
100 pounds malt sprouts.
150 pounds corn meal.
50 pounds cottonseed meal.
Mix and feed 7 pounds (7 to 8 quarts) daily.

II.

150 pounds distillers' grains.
150 pounds standard middlings.
100 pounds corn or hominy meal.
Mix and feed 7 pounds or quarts daily.

III.

150 pounds distillers' grains.
50 pounds corn or hominy meal.
50 pounds cottonseed meal.
Mix and feed 7 pounds or quarts daily.

B. Brewers' Dried Grains.

(*a*) *Character of the Grains.*

Brewers' dried grains are the kiln-dried residue from beer manufacture, and consist of a little of the starch and allied substances, together with the hull, germ and gluten of the barley. Most of the true starch is removed by the action of the malt and yeast. Grains that have been dried immediately are of a yellowish green color, and have a faint aromatic smell. Dark-brown colored grains have been injured before being dried, or

[1] Bulletin 108, Kentucky Experiment Station.

have been heated at too high a temperature, thus causing decomposition. Dried grains are fed quite extensively in Europe, and to some extent in the United States. European investigators consider freshly dried grains as healthful as untreated barley, oats or corn. At present there are some 40 breweries in Massachusetts. The residue is practically all sold undried to farmers living in the immediate vicinity. The comparatively small amount of dried grains consumed in this State comes from the vicinity of New York, Chicago and Milwaukee.

(*b*) *Composition of the Grains* (*Per Cent.*).

	Brewers' Grains (Average 19 Samples).	Wheat Bran for Comparison.
Water,	10.0	10.0
Ash,	3.6	6.2
Protein,	24.0	16.1
Fiber,	13.4	10.5
Extract matter,	42.8	52.6
Fat,	6.2	5.0

In chemical composition the brewers' grains differ from the bran in having noticeably more protein, somewhat more fiber and less extract matter. Two samples of grains recently collected show 27 and 33 per cent. of protein; the latter figure is unusual, and may have been due to the use of some corn in the mash.

(*c*) *Comparative Digestibility.*

On the basis of the average analysis, 100 pounds of the brewers' grains and of the bran contain the following amounts of digestible nutrients: —

	Brewers' Grains (Per Cent.).	Wheat Bran (Per Cent.).
Protein,	19.4	12.4
Fiber,	6.6	3.9
Extract matter,	24.4	37.8
Fat,	5.5	2.8
Total,	55.9	56.9

Each of the two feedstuffs contains substantially the same amounts of digestible nutrients. The net energy values expressed in therms are as follows: brewers' dried grains, 56; wheat bran, 49; or the brewers' grains are worth 10 per cent. more than the bran.

An experiment conducted at this station with 6 dairy cows, in which brewers' grains were compared with wheat bran, led to the following conclusions: —

1. The brewers' grains ration produced slightly more live weight, milk and milk ingredients than did the bran ration.

2. Brewers' grains did not show any objectionable effect either on the general condition of the animal or on the flavor and keeping quality of the milk. They are nearly as bulky as bran, and serve as a distributor of the heavy concentrates.

(*d*) *The Use of Brewers' Grains.*

Only those grains that have a light color and are free from rancidity or sour taste and smell should be used. Grains that have stood for any length of time before drying have fermented, and are not satisfactory as a food.

For Horses. — Brewers' dried grains serve excellently as a partial oat substitute for horses, 2 pounds of the grains being equivalent to 2½ pounds of oats.[1] Voorhees [2] states that brewers' dried grains are a wholesome, nutritious and palatable horse feed. He recommends for work horses, on the basis of 1,000 pounds live weight, 2 pounds bran, 4 pounds corn, 8½ pounds brewers' grains and 6 pounds hay. Very satisfactory results are reported when hard-worked team horses received a daily ration of brewers' dried grains and hay.[1] The total amount of dried grains to be fed daily will naturally depend upon the size of the animal and the amount and character of the work performed. From 3 to 8 pounds may be considered satisfactory, the balance of the grain to consist of corn and oats, or corn and wheat bran.

For Pigs. — Because of their deficiency in ash and starch, and of the excess of hulls, the dried grains are not to be partic-

[1] Pott, already cited, pp. 241, 242.
[2] Bulletin 92, New Jersey Experiment Station.

ularly recommended either for growing or fattening pigs. When fed in connection with skim milk in place of corn, they have not produced as satisfactory a gain in live weight.

For Fattening Cattle. — The brewers' grains are quite satisfactory for fattening beef animals, in the proportion, by weight, of one-third of the grains and two-thirds of corn.

For Milk Production. — The dried grains are very satisfactory as a food for the production of milk; they may be used in place of wheat bran.

I.	II.
125 pounds brewers' grains.	150 pounds brewers' grains.
100 pounds corn or hominy meal.	75 pounds flour middlings.
75 pounds cottonseed meal.	50 pounds cottonseed meal.
Mix and feed 7 pounds or quarts daily.	Mix and feed 7 pounds or quarts daily.

III.

100 pounds brewers' grains.
100 pounds coarse middlings.
100 pounds gluten feed.
Mix and feed 7 pounds (8 quarts) daily.

The above rations are for average-sized cows yielding 10 to 12 quarts of average milk daily. The amount may be increased or diminished, depending upon size of animals, yield of milk, etc.

For Young Stock. — Because of their deficiency in ash, not over 25 per cent. of the grain ration should consist of brewers' dried grains. They may be combined with bran, coarse middlings and cottonseed meal, by weight, one-fourth brewers' grains, one-half coarse middlings, one-fourth cottonseed meal; or one-fourth brewers' grains, one-fourth corn and cob meal, one-fourth coarse middlings, one-fourth cottonseed meal.

(*e*) *Brewers' Wet Grains.*

Brewers' wet grains contain 75 to 77 pounds of water in 100, and are practically all sold to farmers living in the immediate vicinity of the brewery, at prices ranging from 10 to 12 cents a bushel. Assuming that 33 bushels weigh a ton, the cost would

be from $3.30 to $4 at the brewery, to which the cost of cartage should be added. Four tons of wet grains contain nutritive material equivalent to that found in 1 ton of dry grains, or in 1.1 tons wheat bran, or in ¾ ton gluten feed. With these data at hand, the purchaser of this material can calculate at what price he can secure an equal amount of nutrients in the various dry feedstuffs. The writer has not had any experience in feeding wet grains, but believes that 25 pounds is a fair allowance daily for average-sized cows.[1] In addition, 2 to 4 pounds of dry grain may be fed daily, such as a mixture of equal parts by weight of (1) mixed wheat feed and gluten feed, (2) wheat bran and fine middlings, or (3) wheat bran and corn meal.

The succulency of the wet grains is a factor not to be overlooked in estimating the value of the feed. It is not believed that the brewers' wet grains are an objectionable feedstuff when fed in a fresh condition and in moderate quantities. It must be remembered, however, that they are likely to spoil easily, excepting when the temperature is low, and the partly decomposed grains would not be considered suitable for producing first-class milk. When milk is intended for the use of infants, young children or invalids, it is better not to use the wet grains.

C. Malt Sprouts.

(a) *Method of Preparation.*

Malt used in the manufacture of beer is prepared by moistening barley and allowing it to sprout in a warm atmosphere, thus producing a ferment called diastase, which readily converts starch into sugar. After the sprouting process has continued a number of days, the barley is dried, the sprouts removed by machinery and sold for cattle feed; each 100 pounds of malted barley yields about 4 pounds of sprouts. Sprouts of first quality are about ¼ of an inch long, thread-like in appearance, slightly curled, of a yellow or of a brownish yellow color, and form a crisp, porous and bulky mass. Mixed with the sprouts one often notes more or less malted barley kernels.

[1] It is understood that 50 or more pounds are frequently fed daily. It is believed, however, that the smaller quantity is preferable when the grains are fed continuously, and it is desired to retain the same animals in the herd from year to year.

dust and ash. The presence of the dust and ash is due to the fact that some of the sprouts are particularly rich in ashy matter, and because this ashy matter and dust have not been fully removed. Well-cleaned sprouts should be given the preference.

(b) Composition (Per Cent.).

	Average 32 Samples.	Average German Sprouts.[1]
Water,	11.0	10.0
Ash,	5.9	7.2
Protein,	26.4	24.4
Fiber,	12.3	14.0
Extract matter,	43.1	42.4
Fat,	1.3	2.0
Total,	100.0	100.0

The sprouts are characterized by a high percentage of crude protein, considerable fiber and little fat. While the nitrogenous matter in the sprouts is usually designated as true protein, it is well known that from one-fourth to one-third of the nitrogen exists in the form of amids,[2] hence the sprouts contain about 18 per cent. of true protein. Amid bodies are sources of heat and energy, and seem to protect the rapid breaking up of the true protein in the animal body, but they cannot produce flesh or milk casein. The extract matter contains a large amount of cane sugar, a little invert sugar and a considerable amount of pentosans. The fiber content is often increased by the presence of barley hulls. The ash is rich in potash and phosphoric acid and deficient in lime.

[1] E. Pott, already cited, p. 222.

[2] In the process of growth the plant elaborates the nitrates of the soil, first, into amid compounds, — partially developed protein, — and finally into the completed product, or true protein which is largely deposited in the seed. When the seed begins to sprout the true protein is converted back into the soluble amids, to enable the young sprouts to utilize it. Amids may be defined, so far as their use in the plant is concerned, as transportable protein.

(c) *Digestibility.*

One hundred pounds contain: —

	Pounds.
Protein,	20.1
Fiber,	12.2
Extract matter,	36.6
Fat,	1.1
Total,	70.0

The sprouts have a relatively high digestibility and a net energy value of 56.4, just about equivalent to that for brewers' dried grains.

(d) *The Use of Malt Sprouts.*

Malt sprouts are at present used in considerable quantities as a component of many proprietary dairy feeds. They are particularly suited for dairy animals and for fattening cattle.

For Dairy Cows. — This station compared malt sprouts with gluten feed, using four animals in two three-week periods. The malt-sprout ration gave as satisfactory results as did the gluten-feed ration. Foreign investigators state that they are valued for milk production because of the stimulating effect of the amido bodies (and perhaps, also, of the betain and cholin which they contain) upon the mammary glands. If over 2 pounds daily are fed, it is advisable to mix them with water, otherwise digestive disturbances may result. Fed in dry condition in any considerable amount they are likely to be refused by many animals.

I.

100 pounds malt sprouts.
100 pounds corn meal.
100 pounds cottonseed meal.
Mix and feed 7 pounds (7 to 8 quarts) daily.

II.

100 pounds malt sprouts.
125 pounds rye feed.
75 pounds cottonseed meal.
Mix and feed 7 pounds (7 to 8 quarts) daily.

III.

3 pounds (5 quarts) malt sprouts.
2 pounds (3½ quarts) brewers' grains.
2 pounds (1½ quarts) fine middlings.

IV.

3 pounds (5 quarts) malt sprouts.
2 pounds (2 quarts) hominy meal.
2 pounds (1½ quarts) cottonseed meal.

In case of rations III. and IV., it would be advisable to thoroughly moisten the sprouts and then mix the other two grains with them. If the sprouts are not fed in excess of 2 pounds daily, they can replace wheat bran pound for pound in any grain ration. An excess of sprouts is to be avoided because they are deficient in lime, and also because they are likely to cause abortion and possible failure to breed. Pott states that over 3.5 pounds daily are likely to impart an aromatic bitter taste to the milk, sometimes diminishing and sometimes increasing its fat content.

For Fattening Oxen. — Some 2 to 4 pounds daily of malt sprouts (moistened) mixed with corn meal can be utilized with good results for fattening cows or steers.

For Young Calves. — According to F. Lehmann,[1] after the animals are three months old, malt sprouts, thoroughly moistened with boiling water, can be fed lukewarm, beginning with small amounts and gradually increasing to 1 to 2 pounds per day. A few pounds per day can also be fed to growing stock, mixed with middlings and corn meal if the animals receive a good quality of hay.

For Horses. — German feeders frequently, with satisfactory results, feed to horses 2 to 5 pounds daily of malt sprouts moistened with water, in place of a like amount of oats. The sprouts should be fed in small amounts at first (1 pound daily), until the animals become accustomed to them.

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[1] Pott, already cited, p. 226.

THE FEEDING VALUE OF APPLE POMACE.

BY J. B. LINDSEY.

There is often considerable discussion in the agricultural press and among farmers concerning the value of apple pomace as a food for dairy and beef cattle. With a view to getting a few positive data, this station instituted a number of experiments, the results of which are here briefly stated.

(*a*) *Composition of Apple Pomace* (*Per Cent.*).

	Water.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sample I., ...	81.40	.73	.94	3.00	13.03	.90
Sample II., ...	80.20	.60	1.01	3.19	13.73	1.27
Corn silage for comparison, .	80.00	1.10	1.70	5.40	11.10	.70

It will be seen from the above figures that apple pomace is a carbohydrate feed similar to corn silage. It contains about the same amount of water, rather less protein and fiber, and a larger proportion of extract matter. Whether the extract matter in the pomace is as valuable, pound for pound, as that contained in the corn, has not been thoroughly demonstrated.

(*b*) *Digestibility of Apple Pomace.*

The value of a feed cannot always be measured by its composition. A food is valuable as a source of nutrition only in so far as its various constituents can be digested and assimilated. This station has made two different experiments to ascertain the digestibility of the pomace, and the detailed results are to be found in the seventeenth report of this station. The summary follows: —

Summary of Experiments (Per Cent.).

	Number of Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Apple pomace (first experiment).	3	72.5	54.7	–	61.6	84.5	47.2
Apple pomace (second experiment).	3	70.6	42.8	–	67.3	84.3	43.4
Average, ...	6	71.5	48.7	–	64.4	84.4	45.3
Dent corn silage (for comparison).	17	64.0	–	52.0	62.0	69.0	85.0
Flint corn silage (small varieties).	11	75.0	–	65.0	77.0	79.0	82.0

The results show the total dry matter in apple pomace to be about as digestible as in the best grades of silage. The protein content of the pomace is small, — about 1 per cent., — and it has not been possible, by present methods, to ascertain its digestibility. Judging from the composition and digestibility of the pomace, one would feel justified in assuming that, pound for pound, it should approach in feeding value an average quality of corn silage.

(*c*) *Experiments with Dairy Animals.*

While this station has not carried out any exhaustive comparative tests with pomace and other coarse feeds, it has fed the pomace a number of seasons to dairy animals. The material was drawn fresh from the mill, and placed in a large pile under cover. A noticeable quantity of juice gradually drained from it, but it kept in good condition for two months. The animals received from 15 to 30 pounds daily, ate it readily, and the results were quite satisfactory. In one case 2 cows were fed alternately, four weeks at a time, on grain and hay, and on grain, hay and pomace; 25 pounds of pomace were compared with 5 pounds of hay. During the pomace period the animals produced 1,153 pounds of milk, and gained 24 pounds in live weight; during the hay period, 1,138 pounds of milk, and lost 6 pounds in weight. On this basis 5 pounds of pomace were more than equivalent to 1 pound of hay. Judging from this feeding test, and from the composition and digestibility of the

pomace, it seems probable that 4 pounds, when fed in what is termed a "balanced ration," would be equal in feeding value to 1 pound of good cow hay.

The Vermont Experiment Station has fed apple pomace for four years, using in all 20 cows in the several trials. The pomace was shoveled into the silo, leveled off, and kept in good condition without further care. In some cases it was placed on top of the corn silage after the latter had settled. The quantity fed varied from 10 to 35 pounds daily, with no unfavorable effects. As a result of the several experiments, the Vermont station concludes that the pomace is equivalent in feeding value to an equal weight of average corn silage,[1] and that it is without injurious effect on the flavor of milk and butter.

Farmers are cautioned not to feed too large quantities at first, but to begin with 10 pounds daily, and to gradually increase the quantity to 30 pounds, taking a week or more in which to do it. In this way, danger of a sudden milk shrinkage or of the animals getting "off feed," as is sometimes reported, may be avoided. Judging from all the data available, it is believed that farmers living in the vicinity of cider mills will find it good economy to utilize the pomace as a food for their dairy stock.

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[1] There is doubt in the mind of the writer whether pomace would prove equal to well-preserved and well-eared corn silage; it certainly would approach it in feeding value, and ought to be fully utilized.

THE EFFECT OF PROTEIN UPON THE PRODUCTION AND COMPOSITION OF MILK.

BY J. B. LINDSEY.

Investigations and observations indicate that milk is not a simple fluid secreted directly by the blood, but a complex substance resulting from the activity of the milk cells. The cells and milk glands take from the blood and lymph vessels materials suited to their purpose, and by chemical and physiological processes convert them into a different substance, namely, milk. Milk, therefore, consists for the most part of reconstructed cell substance, and it is not possible, by any system of feeding, to produce very great modification in its composition. The composition of milk depends principally upon the breed and individuality of the cow, stage of lactation, and development of the milk cells.

German investigators, during the years 1868 to 1876, studied the additions to the different basal rations of increasing amounts of protein upon the composition of the milk, and noted only very slight variations. Danish observers, as a result of experiments by the group method with 1,152 cows, concluded that the protein was practically without influence in varying the proportions of the several milk ingredients. American experimenters report similar conclusions.

This station, from time to time, has conducted a number of experiments to observe the influence of different amounts of protein in increasing the quantity of milk, to note the protein requirements of dairy animals, and also to study its influence in modifying the proportions of the several milk ingredients. Some of these results have been published in reports of the station, and they have been recently summarized in detail in Part I. of this report. The following are the principal conclusions: —

1. By protein minimum is meant the amount of digestible protein required to support the daily life of an animal of 1,000 pounds live weight, and amounts to about .7 of a pound of crude protein daily; it also includes the amount contained in the milk, which is about .035 of a pound for each pound of milk, or .7 of a pound for 20 pounds of milk. Hence the protein daily minimum for a 1,000-pound cow producing 20 pounds of milk would be substantially 1.4 pounds of digestible protein.

2. A large excess of digestible protein (1.5 pounds, or 100 per cent.) above the protein minimum increased the flow of milk some 15 per cent. in experiments extending over periods of four weeks.

3. No particular difference was noted in the milk yield in case of two herds of cows receiving the same amount of total digestible matter, one receiving 65 per cent. and the other 122 per cent. of digestible protein above the protein minimum. Such a result indicates, at least, that the former excess was sufficient.

4. A 50 per cent. excess of digestible protein daily above the protein minimum in an experiment by the reversal method, extending over a period of nine weeks, produced some 5.9 per cent. more milk than did a ration with 21 per cent. excess protein.

5. Under similar conditions an excess, above the minimum, of 65 per cent. digestible protein produced 7.4 per cent. more milk than did an excess of 39 per cent. (Experiment covered twenty-six days.)

6. In Experiment VI., extending over a period of eleven weeks, with 12 cows by the group method, an excess of .54 of a pound of protein, 31.3 per cent., over the protein minimum, produced an apparent increase of 10 per cent. in the milk yield.

7. In Experiment VIII., extending over periods of twenty-four to thirty weeks, with 10 cows by the group method, the cows receiving the protein minimum did not shrink any more than those receiving each .44 of a pound daily, or 28 per cent., protein above the minimum.

The group method of experimentation is best suited for conducting experiments where a relatively large number of

animals — 20 or more — is available. With a less number the influence of individuality is altogether too pronounced.

8. An excess of 30 per cent. of digestible crude protein above the protein minimum (equal to 1.80 pounds of protein per day) will be productive of satisfactory results in case of cows weighing 900 pounds and producing daily 12 quarts of 4 per cent. milk.[1]

An excess of 50 per cent. of digestible crude protein above the protein minimum is believed to be ample for all ordinary requirements.

9. Protein in excess of the above-suggested amounts may temporarily increase the milk yield, but it seems probable that in many cases the influence of individuality is likely to be more pronounced than the effect of the protein consumed.

10. Under the usual conditions, varying amounts of protein appear to be without influence upon the composition of the milk.

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[1] Armsby, in Farmers' Bulletin No. 346, United States Department of Agriculture, expresses substantially the same idea in allowing .05 of a pound of digestible true protein for each pound of average milk, in addition to the maintenance requirement of .5 of a pound of digestible true protein per 1,000 pounds live weight. It is possible that animals can even do very good work with .04 of a pound of protein for each pound of milk.

INDEX.

INDEX.

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OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

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